DOCUMENT RESUME

ED 317 839	CE 054 709
AUTHOR	Hevel, David
TITLE	Heating and Air Conditioning. Auto Mechanics Curriculum Guide Module 9. Instructor's Guide.
INSTITUTION	Missouri Univ., Columbia. Instructional Materials Lab.
SPONS AGENCY	Missouri State Dept. of Elementary and Secondary Education, Jefferson City. Div. of Vocational and Adult Education.
PUB DATE	Jul 89
NOTE	326p.; For related documents, see CE 054 320-321.
AVAILABLE FROM	Instructional Materials Laboratory, University of Missouri, 2316 Industrial Drive, Columbia, MO 65202 (Order No. 70-1809-I: $22.70).
PUB TYPE	Guides - Classroom Use - Guides (For Teachers) (052)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	*Air Conditioning; *Auto Mechanics; Competence; *Competency Based Education; *Heating; Job Skills; Learning Modules; Mechanics (Process); *Motor Vehicles; Postsecondary Education; Repair; Secondary Education; State Curriculum Guides; Teaching Methods; Units of Study; Vocational Education
IDENTIFIERS	*Missouri

ABSTRACT

This unit of instruction is one of a series of modules in the Missouri Auto Mechanics Curriculum Guide. The module's format was developed for competency-based teaching and testing. The module contains 11 units, each of which contains the following components: a competency profile, objective sheets, references, notes to the instructor, lesson plans, information sheets, assignment sheets, job sheets, and tests and answers. The units cover the following topics: (1) principles of automotive air conditioning; (2) automotive air conditioning system design; (3) automotive air conditioning system service; (4) servicing the automotive air conditioning system; (5) the automotive air conditioning compressor and compressor clutch; (6) repairing and replacing the evaporator, condenser, expansion tube, and receiver-drier; (7) the automotive heating system and engine cooling system; (8) repairing the automotive heating and engine cooling system; (9) electrical components of automotive air conditioning and heating systems; (10) diagnosing and repairing automotive heating and air conditioning control devices; and (11) diagnosing automatic and semiautomatic control systems. (KC)

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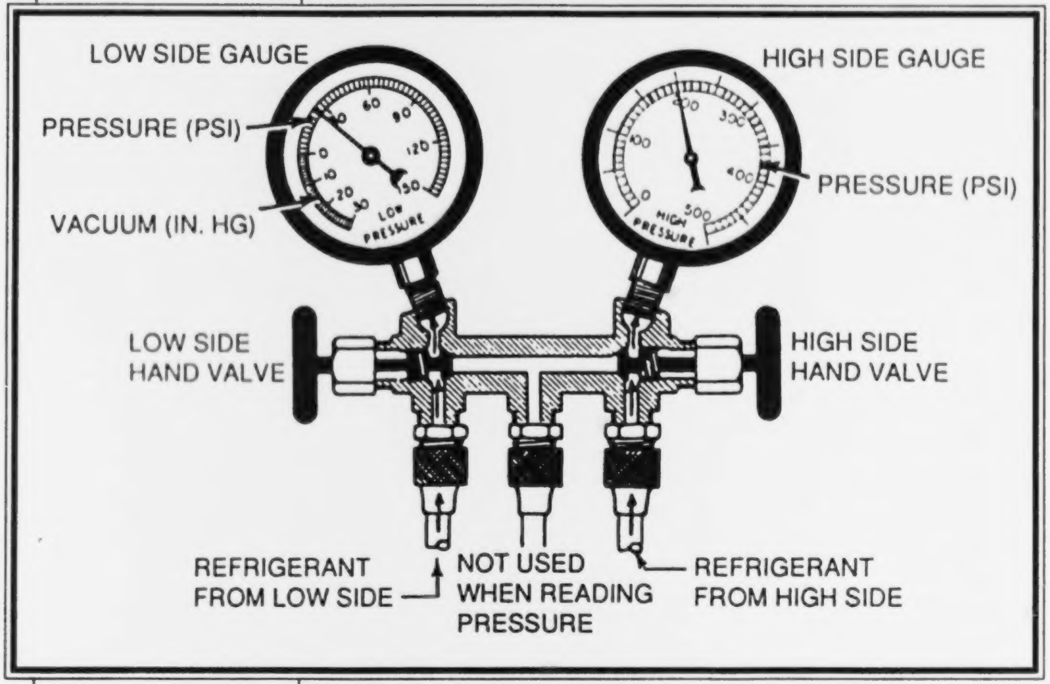
ED317839

70-1809-I
Instructor's Guide

Auto Mechanics

Curriculum Guide


LOW SIDE GAUGE
HIGH SIDE GAUGE
PRESSURE (PSI)
VACUUM (IN. HG)
PRESSURE (PSI)
LOW PRESSURE
HIGH PRESSURE
LOW SIDE HAND VALVE
HIGH SIDE HAND VALVE
REFRIGERANT FROM LOW SIDE
NOT USED WHEN READING PRESSURE
REFRIGERANT FROM HIGH SIDE

Module 9

Heating and Air Conditioning

Produced by
Instructional Materials Laboratory
In cooperation with the Dept. of
Elementary and Secondary
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MODULES INCLUDED IN THE AUTO MECHANICS CURRICULUM GUIDE

INTRODUCTION TO AUTO MECHANICS
ELECTRICAL SYSTEMS
ENGINE PERFORMANCE
ENGINE REPAIR
SUSPENSION AND STEERING
BRAKES
MANUAL DRIVE TRAIN AND AXLES
AUTOMATIC TRANSMISSION AND TRANSAXLES
HEATING AND AIR CONDITIONING

The activity which is the subject of this report was supported in whole or in part by funds from the Department of Elementary and Secondary Education, Division of Vocational and Adult Education. However, the opinions expressed herein do not necessarily reflect the position or policies of the Missouri Department of Elementary and Secondary Education or the Division of Vocational and Adult Education, and no official endorsement should be inferred.

AUTO MECHANICS CURRICULUM

MODULE 9: HEATING AND AIR CONITIONING

INSTRUCTOR'S GUIDE

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314/882-2884
July 1989

Catalog No. 70-1809-I

FOREWORD

Once again, we are indebted to the teachers and administrators who provide their time, efforts, and professionalism to develop curriculum for trade, technical, and industrial education programs. The Heating and Air Conditioning module (the last of nine modules to make up the Missouri Auto Mechanics Curriculum Guide) is an outstanding example of what can be accomplished when the right people with the right attitude work together. The curriculum writers and subject matter experts who worked on this guide are to be commended for a job well done.

The module's format has been developed for competency-based teaching and testing. Job sheets within the guide evaluate specific competencies and can be managed with the Vocational Administrative Management System (VAMS). All major components of the module have been keyed to the Missouri Auto Mechanics Competency Profile, which was developed by industry and education professionals within Missouri.

Special appreciation is given to David Hevel, the module's writer. Special appreciation is also given to Roger Donovan, who served as a technical adviser during production of the module.

The format and curriculum management system found in this module may be new to many vocational educators. However, we are confident that, when used as designed, this module will allow for a more productive and rewarding educational experience for both teacher and student. Any future auto mechanics curriculum modifications will begin with the Missouri Auto Mechanics Curriculum Guide. Auto mechanics, like many technical fields, is undergoing constant and considerable change. We will annually evaluate the need to update this guide on a module-by-module basis. Your suggestions regarding areas for improvement are both encouraged and appreciated.

Judith Moore, Supervisor
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Department of Elementary and Secondary Education

Charles Waibel, Director
Industrial Education
Department of Elementary and Secondary Education

ACKNOWLEDGEMENTS

Heating and Air Conditioning is the last of nine modules that make up the Missouri Auto Mechanics Curriculum Guide. Produced by the Instructional Materials Laboratory (IML), the guide represents a continuing commitment to Missouri's Vocational Instructional Management System (VIMS). All modules in the guide are based on the Missouri Auto Mechanics Competency Profile, which in turn is based on and cross-referenced to the ASE task list. For years ASE has set the professional standards for automotive technicians. Therefore, a strong ASE orientation makes the guide an effective tool for preparing students to enter the technologically advanced field of auto mechanics.

IML extends special recognition to David Hevel, the writer of Heating and Air Conditioning. Mr. Hevel's thorough knowledge of automotive technology and years of teaching experience are evident throughout his work. Special recognition also goes to Roger Donovan, who contributed heavily to the module as a technical adviser. Mr. Donovan's attention to technical detail proved invaluable throughout the module's development.

IML gratefully acknowledges the important contribution of the advisory committee, which, among other tasks, developed the competency profile for the guide. The advisory committee members are listed below:

Advisory Committee Members

Charles Waibel and Judith Moore, Division of Vocational and Adult Education, Department of Elementary and Secondary Education, Jefferson City, Mo.
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Darwin Kraenow, Linn Technical College, Linn, Mo.

IML also acknowledges the fieldtesters, who worked to ensure that the Heating and Air Conditioning module was developed into an effective and practical teaching tool. The fieldtesters are listed below:

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Robert Barbarick, Four Rivers AVTS, Washington, Mo.
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Ted Scarbrough, Arcadia Valley AVTS, Ironton, Mo.
Wayne Sweatt, Lake AVTS, Camdenton, Mo.

The support and contributions of the following IML staff members were instrumental to the development of this module:

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HOW TO USE THE MISSOURI AUTO MECHANICS CURRICULUM GUIDE

Every module of the Missouri Auto Mechanics Curriculum Guide contains the following seven major components: (1) a competency profile, (2) objective sheets, (3) information sheets, (4) assignment sheets, (5) job sheets, (6) tests, and (7) a cross-reference table. Below is a discussion of the design of these components.

MISSOURI COMPETENCY PROFILE

The competency profile identifies 144 basic auto mechanics competencies. The profile divides the competencies into nine general areas, each of which serves as the basis for individual modules of instruction (such as the Heating and Air Conditioning module). The competency profile further divides these general areas into duty bands, each of which is identified by a capital letter. An example of a duty band in the Heating and Air Conditioning module would be "Air Conditioning." Under each duty band are listed several competencies, each of which is identified by an Arabic numeral. Note the below excerpt from the competency profile:

3	2	1	N	Gg	Air Conditioning	ASE Task(s)
					1 Diagnose and performance test A/C systems for problems and determine needed repairs	G001 G008 [illegible] G024 G025 G031 G034 G035 [illegible]
					2 Clean, inspect, and repair A/C system components	G013 G020 [illegible] G023 G026 [illegible] G032 G033 G053 G058
					3 Evacuate and charge A/C system and performance test	G002 G003 [illegible]
					4 Diagnose and repair automatic and electrical temperature control units	G046 G051 G059 G067

In this excerpt, the duty band "Air Conditioning" is identified by the letters "Gg." The competency "Clean, inspect, and repair A/C system components" falls under Duty Band Gg and is identified by the Arabic numeral "2." Throughout the Heating and Air Conditioning module, therefore, the competency "Clean, inspect, and repair A/C system components" will be referred to as Competency Gg2.

Also note that one or more ASE tasks are listed to the right side of each competency on the profile. These ASE tasks are directly related to those competencies by which the tasks appear.

(**NOTE:** The term "cross-reference table" will appear throughout the rest of this discussion. A cross-reference table is a chart that shows precisely how objectives, assignment sheets, test questions, and job sheets are related to individual competencies. The cross-reference table will be discussed later in more detail.)

INFORMATION SHEETS

The information sheets (or information outline) present the student with important facts and concepts relating to basic automotive technology and service procedures. The information sheets also explain why a procedure is necessary and why it must be performed in a certain manner. Though not intended to be as comprehensive as a textbook, the information sheets provide a good source of information to which the student can refer outside of class. Perhaps the information sheets can best be thought of as a thorough set of notes accompanying the instructor's classroom lecture.

OBJECTIVE SHEETS

The first page of each unit in the guide is an objective sheet, which states the unit's general and specific objectives. Below is the objective sheet for Unit VII of the Heating and Air Conditioning module:

MODULE: HEATING AND AIR CONDITIONING

UNIT VII: THE AUTOMOTIVE HEATING SYSTEM AND ENGINE COOLING SYSTEM

UNIT OBJECTIVE

After completing this unit, the student should be able to identify the principles by which a vehicle's heating system operates and diagnose and repair the system. The student will demonstrate mastery of the material by achieving a score of _____ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1. I. Identify terms and definitions associated with heating system operation (Competency Hh1, Unit VII Test).

II. Identify the principles by which the heater core operates (Competency Hh1, Unit VII Test).

III. Identify systems that control the heater core (Competency Hh1, Unit VII Test).

IV. Identify the principles by which the engine cooling system operates (Competency Hh1, Unit VII Test).

Lesson 2. I. Identify procedures for diagnosing heating system problems (Competency Hh1, Unit VII Test).

II. Identify procedures for diagnosing leaks within the heating system (Competency Hh1, Unit VII Test).

III. Demonstrate the ability to:

a. Diagnose the vehicle's heating system (Competency Hh1, JS1-L2-UVII).

b. Diagnose coolant leaks in the vehicle's heating system (Competency Hh1, JS2-L2-UVII).

c. Diagnose thermostat malfunction in the vehicle's heating system (Competency Hh1, JS3-L2-UVII).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks G036-G038.

Notice that the specific objectives are designated by Roman numerals. Also notice that the competency (or competencies) to which each objective relates is listed in parentheses behind each objective. Also listed in parentheses is the method by which the student's ability to perform the objective is evaluated.

A note identifying the ASE tasks that are covered by the unit's job sheets appears at the end of every objective sheet.

ASSIGNMENT SHEETS

The assignment sheets serve one of two functions: they can either emphasize important cognitive information or instruct students in developing procedures specific to a particular vehicle. The "Notes to the Instructor," found on the table of contents section of each module, indicates how each assignment sheet is used.

(**NOTE:** Assignment sheets are not used to evaluate competencies directly. Only job sheets directly evaluate competencies.)

UNIT TESTS

Unit tests cover information relating to specific competencies. The student must obtain acceptable test scores (decided upon by the instructor) before receiving an evaluation for these competencies. (Since job sheets are used to evaluate competencies, the student, therefore, must receive an acceptable test score before doing certain job sheets.) The test ensures that the student has the minimum knowledge required to perform the competencies covered on the job sheets. On some tests, all the questions cover information that relates equally to a single competency or a group of competencies. At the end of these tests, a note like the following appears:

> (NOTE: The student must obtain a minimum score of _____ on the Unit III Test in order to receive an evaluation for Competency Gg1.)

On other tests, one group of questions covers information related exclusively to one particular competency while another group of questions relates exclusively to another particular competency. Questions relating to an individual competency (or a group of specific competencies) are divided into parts. At the end of each part, a note like the following appears:

> (NOTE: The student must obtain a minimum score of ____ on Part I of the Unit IV Test in order to receive an evaluation for Competency Gg3.)

All the job sheets and test questions related to each competency are listed on the module's cross-reference table. The cross-reference table allows the instructor to determine what unit tests (or what parts of unit tests) a student must successfully complete before being eligible to perform the job sheets related to a particular competency. By observing the end-of-test notes and using the cross-reference table, the instructor can easily determine what job sheets a student is eligible to do as a result of his or her score on a particular test or part of a test.

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JOB SHEETS

Besides giving the student practical, hands-on experience in auto mechanics, job sheets provide a means of evaluating a student's ability to perform the competencies. The job sheets are, therefore, the key component of the Missouri Auto Mechanics Curriculum Guide. Below is an excerpt from the first page of a typical job sheet in the Heating and Air Conditioning module:

JS1-L2-UVII

MODULE: HEATING AND AIR CONDITIONING

DIAGNOSING AN AUTOMOTIVE HEATING SYSTEM

Equipment:

Service manual
Selected vehicle
Safety glasses

Procedure: Evaluation 3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___
2. Using the procedure outlined below, performance test the heater system. ___ ___ ___ ___

Notice that the job sheet is identified as JS1-L2-UVII, which translates into Job Sheet 1, Lesson 2, Unit VII. This shorthand system of job sheet identification is used throughout the curriculum guide.

(**NOTE:** Assignment sheets are identified with the same shorthand system. Assignment Sheet 1, Lesson 1, Unit X would be AS1-L1-UX.)

(**NOTE:** Both job sheets and assignment sheets are numbered consecutively within unit lessons.)

Also notice that, in the above job sheet excerpt, the spaces to the right of the page allow the instructor to evaluate the student on a particular job sheet activity. These spaces appear only by numbered items, which represent significant tasks; therefore, the instructor is freed from having to evaluate the minor steps of a procedure. At the beginning of each job sheet, the heading "3 2 1 N" indicates the four possible evaluations a student can receive. The meaning of the numbers and the letter N is as follows:

3 = Mastery - can work independently with no supervision
2 = Requires supervision - can perform job completely with limited supervision
1 = Not mastered - requires instruction and close supervision
N = No exposure - no experience or knowledge in this area

The individual evaluations made throughout a job sheet are averaged together at the end of the job sheet. A note at the end of the job sheet explains how this average relates to the final evaluation for a particular competency. Below is an example of a note found at the end of a typical job sheet. The note explains that the average of the individual evaluations made throughout the job sheets is the final evaluation for Competency E3:

Average of above evaluations* ____

(*This is the final evaluation for Competency E3.)

As automotive instructors know, an automobile contains many complex and interrelated components. A single general service task may involve several different procedures. In the Missouri Auto Mechanics Curriculum Guide, therefore, a competency may be evaluated over several job sheets; also one job sheet may evaluate several competencies. As will be demonstrated later, each job sheet is accompanied by a thorough set of instructions, explaining how each of the final job sheet averages is to be used. The cross-reference table is also quite helpful in showing which job sheets evaluate which competencies.

CROSS-REFERENCE TABLE

The cross-reference table can quickly reveal how competencies relate to instructional objectives, job sheets, and test items. Note the following excerpt from the Heating and Air Conditioning module cross-reference table:

MODULE: HEATING AND AIRCONDITIONING
CROSS-REFERENCE TABLE OF INSTRUCTIONAL MATERIALS

Gg2	UI-L1-I, UI-L1-II, UI-L2-I, UI-L2-II; UII-L1-I, UII-L1-II, UII-L1-III, UII-L2-I, UII-L2-II, UII-L2-III; UIV-L1-IVf; UV-L1-I, UV-L1-II, UV-L1-III, UV-L1-IV, UV-L1-Va, UV-L1-Vb, UV-L1-Vc, UV-L1-Vd; UVI-L1-I, UVI-L1-II, UVI-L1-IIIa, UVI-L1-IIIb, UVI-L1-IIIc, UVI-L1-IIId, UVI-L1-IIIe	AS1-L1-UIV AS2-L1-UIV AS1-L1-UV AS2-L1-UV AS3-L1-UV AS4-L1-UV AS1-L1-UVI AS2-L1-UVI AS3-L1-UVI	JS6-L1-UIV JS1-L1-UV JS2-L1-UV JS3-L1-UV JS4-L1-UV JS1-L1-UVI JS2-L1-UVI JS3-L1-UVI JS4-L1-UVI JS5-L1-UVI	UI 1-20 UII 1-40 UV 1-30 UVI 1-19

The above excerpt lists all the instructional objectives in the module that cover Competency Gg2. The cross-reference table also indicates the parts of the various unit tests that cover Competency Gg2. Just as importantly, the table reveals at a glance that the student must perform JS6-L1-UIV, JS1-L1-UV, JS2-L1-UV, JS3-L1-UV, JS4-L1-UV, JS1-L1-UVI, JS2-L1-UVI, JS3-L1-UVI, JS4-L1-UVI, and JS5-L1-UVI before he or she can receive an evaluation for Competency Gg2. By looking at the cross-reference table, the instructor can, therefore, quickly determine what test questions a student needs to answer and what job sheets a student needs to perform before receiving a final evaluation for a particular competency.

HOW AND WHY COMPETENCIES ARE EVALUATED OVER SEVERAL JOB SHEETS

According to the competency profile, Competency Gg2 ("Clean, inspect, and repair A/C system components") covers 23 ASE tasks. A job sheet covering all of these ASE tasks would be unreasonably long and overly complicated. The Missouri Auto Mechanics Curriculum Guide, therefore, allows the student to perform several job sheets in order to receive an evaluation for Competency Gg2. These job sheets are listed below:

JS6-L1-UIV: Checking Compressor Oil
JS1-L1-UV: Replacing the Shaft Seal on an Air Conditioning Compressor
JS2-L1-UV: Replacing Compressor Protection Devices
JS3-L1-UV: Replacing Compressor Reed Plates
JS4-L1-UV: Replacing the Compressor Clutch
JS1-L1-UVI: Inspecting, Testing, and Replacing the Air Conditioning Condenser
JS2-L1-UVI: Replacing a Receiver-Drier
JS3-L1-UVI: Inspecting and Testing an Expansion Valve
JS4-L1-UVI: Replacing an Orifice Tube
JS5-L1-UVI: Inspecting, Testing, Flushing, and Replacing an Evaporator

The activities in the above job sheets satisfy Missouri Competency Gg2 and the ASE tasks that accompany Gg2. At the end of each job sheet relating to Gg2, a note explains that the individual evaluations made throughout the job sheet are averaged together to determine a partial evaluation for Gg2. The note also indicates on what job sheet the final evaluation for Gg2 will be determined. Below is an example of the note:

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency Gg2. Final evaluation for Gg2 will be made at the end of JS5-L1-UVI.)

At the end of JS5-L1-UVI, the following note is found:

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency Gg2. Final evaluation for Gg2 will be made at the end of this job sheet.)

At the end of the job sheet, the following instructions explain how the final evaluation for Gg2 is to be made:

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency Gg2 by averaging the evaluations of JS6-L1-UIV, JS1-L1-UV, JS2-L1-UV, JS3-L1-UV, JS4-L1-UV, JS1-L1-UVI, JS2-L1-UVI, JS3-L1-UVI, JS4-L1-UVI, and JS5-L1-UVI. Use the spaces provided below.

	Evaluation			
	3	2	1	N
JS6-L1-UIV	___	___	___	___
JS1-L1-UV	___	___	___	___
JS2-L1-UV	___	___	___	___
JS3-L1-UV	___	___	___	___
JS4-L1-UV	___	___	___	___
JS1-L1-UVI	___	___	___	___
JS2-L1-UVI	___	___	___	___
JS3-L1-UVI	___	___	___	___
JS4-L1-UVI	___	___	___	___
JS5-L1-UVI	___	___	___	___
Final evaluation for Competency Gg2	___	___	___	___

The content of the Heating and Air Conditioning module is organized in the most teachable manner possible; therefore, content relating to Competency Gg2 is covered in Units IV through VI of the module. The job sheets evaluating Gg2, therefore, appear in all three of these units rather than being grouped together. Again, the job sheet notes and the cross-reference table make it easy to identify and assign the job sheets that relate to a specific competency.

PACKAGING OF THE AUTO MECHANICS CURRICULUM GUIDE

Each module in the Auto Mechanics Curriculum Guide is packaged in three components: an instructor's guide, a student reference, and student work sheets. The instructor's guide includes the following items, all of which are color coded:

Cross-reference table (color-coded white)
Objective sheets (color-coded white)
Table of contents, references, notes to the instructor, answer sheets for assignment sheets and tests (color-coded pink)
Information sheets (color-coded green)
Assignment sheets (color-coded tan)
Job sheets (color-coded blue)
Unit tests (color-coded yellow)

The student reference contains copies of the objective sheets and information sheets from the instructor's guide. The student work sheets include consumable items from the instructor's guide, such as job sheets, assignment sheets, and unit tests. For convenience, the page numbers of the items in the student reference and in the work sheets are the same as those in the instructor's guide; therefore, page numbers in the student reference and work sheets are not consecutive. All student reference pages and work sheet pages are white.

Competency profiles for the guide are packaged in groups of ten along with a copy of the ASE task list.

MODULE: HEATING AND AIR CONDITIONING
CROSS-REFERENCE TABLE OF INSTRUCTIONAL MATERIALS

Competency	Instructional Objective	Assignment Sheet	Job Sheet	Test Item	Notes
Gg1	UI-L1-I, UI-L1-II, UI-L2-I, UI-L2-II; UII-L1-I, UII-L1-II, UII-L1-III, UII-L2-I, UII-L2-II, UII-L2-III; UIII-L1-I, UIII-L1-II, UIII-L1-III; UIV-L1-I, UIV-L1-II, UIV-L1-IVa, UIV-L1-IVb, UIV-L1-IVc, UIV-L1-IVi	AS1-L2-UI AS1-L2-UII AS1-L1-UIII AS1-L1-UIV	JS1-L1-UIV JS2-L1-UIV JS3-L1-UIV JS9-L1-UIV	UI 1-20 UII 1-40 UIII 1-25 UIV 10-30	
Gg2	UI-L1-I, UI-L1-II, UI-L2-I, UI-L2-II; UII-L1-I, UII-L1-II, UII-L1-III, UII-L2-I, UII-L2-II, UII-L2-III; UIV-L1-IVf; UV-L1-I, UV-L1-II, UV-L1-III, UV-L1-IV, UV-L1-Va, UV-L1-Vb, UV-L1-Vc, UV-L1-Vd; UVI-L1-I, UVI-L1-II, UVI-L1-IIIa, UVI-L1-IIIb, UVI-L1-IIIc, UVI-L1-IIId, UVI-L1-IIIe	AS1-L1-UIV AS2-L1-UIV AS1-L1-UV AS2-L1-UV AS3-L1-UV AS4-L1-UV AS1-L1-UVI AS2-L1-UVI AS3-L1-UVI	JS6-L1-UIV JS1-L1-UV JS2-L1-UV JS3-L1-UV JS4-L1-UV JS1-L1-UVI JS2-L1-UVI JS3-L1-UVI JS4-L1-UVI JS5-L1-UVI	UI 1-20 UII 1-40 UV 1-30 UVI 1-19	
Gg3	UI-L1-I, UI-L1-II, UI-L2-I, UI-L2-II; UII-L1-I, UII-L1-II, UII-L1-III, UII-L2-I, UII-L2-II, UII-L2-III; UIV-L1-III, UIV-L1-IVd, UIV-L1-IVe, UIV-L1-IVg, UIV-L1-IVh	AS1-L1-UIV	JS4-L1-UIV JS5-L1-UIV JS7-L1-UIV JS8-L1-UIV	UI 1-20 UII 1-40 UIV 1-9 UIX 1-15 UX 1-15 UXI 1-20	
Gg4	UI-L1-I, UI-L1-II, UI-L2-I, UI-L2-II; UII-L1-I, UII-L1-II, UII-L1-III, UII-L2-I, UII-L2-II, UII-L2-III; UIX-L1-I, UIX-L1-II, UIX-L1-III, UIX-L1-IV, UIX-L1-Va, UIX-L1-Vb, UIX-L1-Vc; UX-L1-I, UX-L1-II, UX-L1-III, UX-L1-IV, UX-L1-V, UX-L1-VI, UX-L1-VIIa, UX-L1-VIIb, UX-L1-VIIc; UXI-L1-I, UXI-L1-II, UXI-L1-III, UXI-L2-I, UXI-L2-II, UXI-L2-III, UXI-L2-IVa, UXI-L2-IVb, UXI-L2-IVc, UXI-L2-IVd	AS1-L1-UIX AS1-L1-UX AS2-L1-UX AS1-L1-UXI AS1-L2-UXI AS2-L2-UXI AS3-L2-UXI AS4-L2-UXI	JS1-L1-UIX JS2-L1-UIX JS3-L1-UIX JS1-L1-UX JS2-L1-UX JS3-L1-UX JS1-L2-UXI JS2-L2-UXI JS3-L2-UXI JS4-L2-UXI	UI 1-20 UII 1-40 UIX 1-15 UX 1-15 UXI 1-20	

Competency	Instructional Objective	Assignment Sheet	Job Sheet	Test Item	Notes
Hh1	UVII-L1-I, UVII-L1-II, UVII-L1-III, UVII-L1-IV, UVII-L2-I, UVII-L2-II, UVII-L2-IIIa, UVII-L2-IIIb, UVII-L2-IIIc	AS1-L2-UVII AS1-L1-UVIII	JS1-L2-UVII JS2-L2-UVII JS3-L2-UVII	UVII 1-25	
Hh2	UVIII-L1-I, UVIII-L1-II, UVIII-L1-III, UVIII-L1-IVa, UVIII-L1-IVb, UVIII-L1-IVc, UVIII-L1-IVd, UVIII-L1-IVe	AS1-L1-UVIII AS2-L1-UVIII	JS1-L1-UVIII JS2-L1-UVIII JS3-L1-UVIII JS4-L1-UVIII JS5-L1-UVIII	UVIII 1-15	

MODULE: HEATING AND AIR CONDITIONING

UNIT I: PRINCIPLES OF AUTOMOTIVE AIR CONDITIONING

UNIT OBJECTIVE

After completing this unit, the student should be able to identify the principles of automotive air conditioning. The student will demonstrate mastery of the material by achieving a score of _____ on the unit test.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1. I. Identify terms and definitions associated with refrigeration (Competencies Gg1-Gg4, Unit I Test).

II. Identify principles of heat energy (Competencies Gg1-Gg4, Unit I Test).

Lesson 2. I. Identify properties of refrigerant 12 (Competencies Gg1-Gg4, Unit I Test).

II. Identify basic heat exchangers within the air conditioning system and the manner in which they function (Competencies Gg1-Gg4, Unit I Test).

ASE TASKS COVERED IN THIS UNIT

I. Only material that is preliminary to ASE tasks appears in this unit; therefore, no ASE tasks are covered directly.

MODULE: HEATING AND AIR CONDITIONING

UNIT I: PRINCIPLES OF AUTOMOTIVE AIR CONDITIONING

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

  1. Lesson 1: PRINCIPLES OF REFRIGERATION

     a. Information outline

  2. Lesson 2: OPERATING PRINCIPLES OF AUTOMOTIVE AIR CONDITIONING SYSTEMS

     a. Information outline

     b. Assignment sheets

        AS1-L2-UI: Principles of Air Conditioning

E. Unit test

F. Answers to unit test

REFERENCES

Carter Carburetor Division, ACF Industries, Inc. *Automotive Air Conditioning Theory and Practice*.

Mitchell Information Services, Inc. *Heating and Air Conditioning Systems*. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1987.

Mitchell International, Inc. *Automotive Air Conditioning Basic Service Training Manual*. 21st ed. San Diego, CA: Mitchell International Inc., 1988.

Mitchell Manuals, Inc. *1984 Edition Automotive Air Conditioning Basic Service Training Manual*. San Diego, CA: Mitchell Manuals, Inc., 1984.

Murray Corporation. *Dealer Education Program Temperature Control Clinic Workbook*. Cockeysville, MD: Murray Corporation, 1988.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

   1. Students should do AS1-L2-UI before taking the Unit I Test.

B. Suggested audio-visual material from The Media Center, State Fair Community College, Sedalia, Mo.

   1. Principles of Refrigeration (AM-83-300), 1983.

MODULE: HEATING AND AIR CONDITIONING

UNIT I: PRINCIPLES OF AUTOMOTIVE AIR CONDITIONING

LESSON 1: PRINCIPLES OF REFRIGERATION

I. Terms and definitions

A. Atmospheric pressure--Air pressure that is measured in pounds per square inch (psi) at a given altitude above sea level. (Atmospheric pressure at sea level is 14.7 psi.)

B. Boiling point--The temperature at which a substance changes from liquid to vapor.

C. British thermal unit (Btu)--A unit of measurement based upon the amount of heat required to increase the temperature of one pound of water by 1°F.

D. Centigrade--A scale used to measure temperature. In the centigrade scale, 0° is the freezing point of water while the boiling point is 100°.

E. Change of state--A fundamental altering of the arrangement of molecules in a substance as it changes from one physical state (solid, liquid, or vapor) to another.

F. Cold--A condition characterized by a low intensity of heat.

G. Condensation--The changing of a vapor to a liquid as a result of heat loss.

H. Conduction of heat--A process by which heat is transferred through a substance.

I. Convection--The process of transferring heat by circulating liquid or vapor.

J. Dichlorodifluoromethane--The chemical name for R-12. R-12 is more commonly known as freon. Freon transfers heat within an air conditioning system.

K. Evaporation--The changing of liquid to vapor as a result of an increase in heat.

L. Fahrenheit--A scale used to measure temperature. In the Fahrenheit scale, 32° is the freezing point of water while 212° is the boiling point.

M. Freon 12--Another term for R-12.

N. Heat--Energy produced by the movement of molecules in any substance above 0° Kelvin (absolute zero).

O. Latent heat of condensation--The quantity of heat that a substance releases while changing from a vapor to a liquid without undergoing a significant change in temperature.

P. Latent heat of evaporation--The amount of heat absorbed by vapor during evaporation. This absorption of heat allows a substance to remain at a constant temperature while undergoing evaporation.

Q. Pressure--Force per unit of area, such as pounds per square inch (psi).

R. Radiation--A process in which heat passes through a substance without increasing the temperature of the substance.

S. Temperature--An amount of hotness or coldness which can be designated by centigrade or Fahrenheit degrees.

T. Vacuum--An area in which pressure is below the surrounding atmospheric pressure. Vacuums are measured in inches of Mercury (Hg).

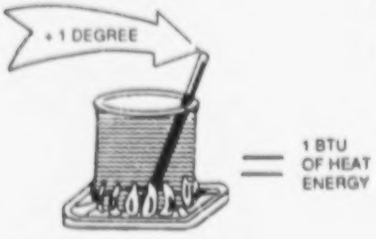
II. Principles of heat energy

A. Heat is a form of energy that can cause a substance to rise in temperature, to fuse, to evaporate, to expand, or to change its basic state. Any substance that has no heat energy is said to be at absolute zero (-459°F). Any substance above absolute zero contains some heat energy.

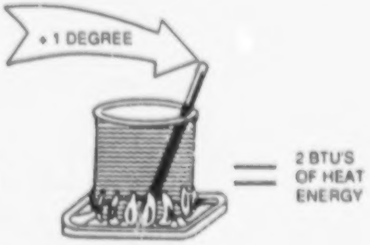
B. Temperature is a measure of the intensity of heat in any substance at a specific time. Temperature does not, however, indicate how much heat energy was required to bring the substance to that temperature or the rate at which the substance was heated.

(NOTE: Temperature can, of course, be measured with either the Fahrenheit or centigrade scale. In the centigrade scale, each degree represents 1/100th of the difference between the freezing and boiling points of water. In the Fahrenheit scale, each degree represents 1/180th of the difference between the freezing and boiling points.)

C. The British thermal unit (Btu) is a unit of heat measurement. One Btu represents the amount of energy required to raise the temperature of one pound of water by 1°F.



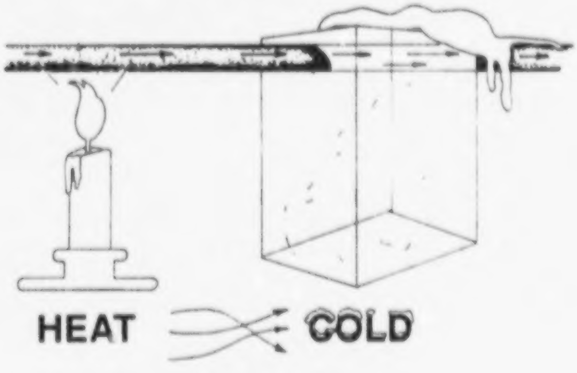
1 POUND OF WATER (LIQUID)



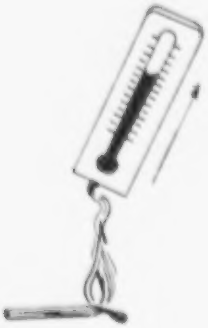
2 POUNDS OF WATER (LIQUID)

D. Conduction, convection, and radiation are three ways in which heat is transferred from one substance to another.

1. Conduction occurs when heat moves from a warm area to a cooler one. During conduction heat energy passes from one molecule to the next.



2. Convection occurs when a liquid or vapor moves heat energy from one area to another.



3. Radiation occurs when a substance increases enough in temperature to allow a measurable amount of heat to escape. Any substance at a temperature above absolute zero radiates some heat.

Courtesy of Mitchell Information Services, Inc

E. A significant increase or decrease in heat can cause a substance to undergo a change of state. Evaporation and condensation each represents a change of state.

1. Evaporation occurs when a liquid absorbs enough heat to boil and change into a vapor.

   (NOTE: When a substance changes its state from liquid to vapor, the vapor absorbs a large amount of heat from the liquid. The temperature of the liquid, therefore, stays the same during the change of state. The heat absorbed by the vapor is referred to as the latent heat of evaporation.)

2. Condensation occurs when a vapor loses enough heat to change into a liquid.

   (NOTE: When a substance changes from a vapor to a liquid, the liquid absorbs heat from the vapor. The temperature of the liquid stays the same during the change, even though the process of condensation is a cooling action. The heat absorbed by the liquid is referred to as the latent heat of condensation or dew point.)

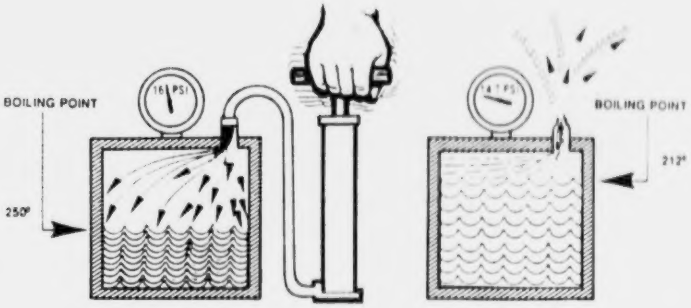
3. Freezing occurs when a liquid loses enough heat to change into a solid.

F. The relationship between pressure, temperature, and change of state

1. There is a direct relationship between a liquid's boiling point and the pressure on the liquid's surface.

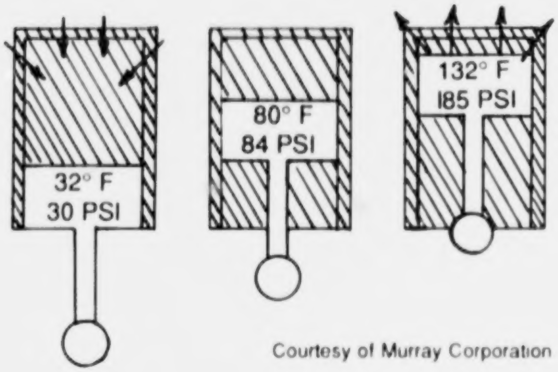
    a. Increasing pressure on a liquid's surface will raise the liquid's boiling point.

    b. Decreasing pressure on the liquid's surface will lower the liquid's boiling point.


BOILING POINT
16 PSI
250°
14.7 PSI
BOILING POINT
212°

2. There is a direct relationship between the temperature of a vapor and the amount of pressure on the vapor.

    a. Increasing the amount of pressure a vapor is under will increase the temperature of the vapor.


32° F
30 PSI
80° F
84 PSI
132° F
185 PSI

Courtesy of Murray Corporation

    b. Decreasing the amount of pressure a vapor is under will decrease the temperature of the vapor.

MODULE: HEATING AND AIR CONDITIONING

UNIT I: PRINCIPLES OF AUTOMOTIVE AIR CONDITIONING SYSTEMS

LESSON 2: OPERATING PRINCIPLES OF AUTOMOTIVE AIR CONDITIONING SYSTEMS

I. Properties of freon

A. Freon has a low boiling point. Freon will boil at -22°F if it is at 14.7 psi (which is atmospheric pressure at sea level).

(**CAUTION:** Because of its low boiling point, freon easily draws heat from any gases or objects that it contacts. Freon can instantly freeze human flesh. When handling freon, always exercise great caution and wear eye protection.)

B. Freon is generally not toxic to humans.

(**CAUTION:** Though not generally dangerous as a poison, freon displaces oxygen and can, therefore, create an asphyxiation hazard. When working with freon, always maintain proper ventilation.)

C. Freon will not corrode aluminum or steel.

D. Freon is soluble in oil (compressor lubricant). Compressor lubricant will flow through an air conditioning system along with the freon.

E. Freon has a wide latent heat evaporation/condensation range; freon can, therefore, cycle through its change of state over a wide temperature and pressure range.

F. Freon maintains a predictable relationship between pressure and temperature. The graph below shows that the boiling point of freon rises in relation to changes in pressure.

REFRIGERANT R-12

Fahrenheit	PSI	Fahrenheit	PSI
—20	0.6	65	63.8
—15	2.4	70	70.2
—10	4.5	75	77.0
— 5	6.7	80	84.2
0	9.2	85	91.8
5	11.8	90	99.8
10	14.6	95	108.3
15	17.7	100	117.2
20	21.0	105	126.6
25	24.6	110	136.4
30	28.5	115	146.8
35	32.6	120	157.7
40	37.0	125	169.1
45	41.7	130	181.0
50	46.7	135	193.5
55	52.0	140	206.6
60	57.7	145	220.3

(R-12 Boiling Point — 21.6° F)

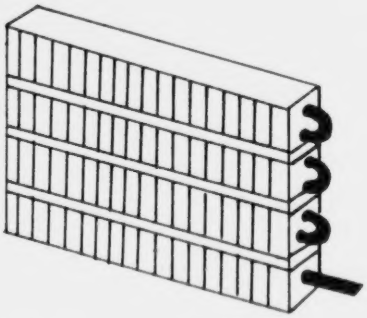
Courtesy of Murray Corporation

II. A typical air conditioning system uses two heat exchangers: the evaporator and the condenser.

A. The evaporator is a radiator-like device located within the heater plenum in the passenger compartment. The evaporator has tubes through which freon circulates. The evaporator also has fins for conducting heat.

B. The condenser is a radiator-like device located in front of the radiator. The condenser has tubes for circulating freon and fins for conducting heat.

C. High-pressure tubing (hoses) connects the outlet of the condenser to the inlet of the evaporator.



D. Function of heat exchangers

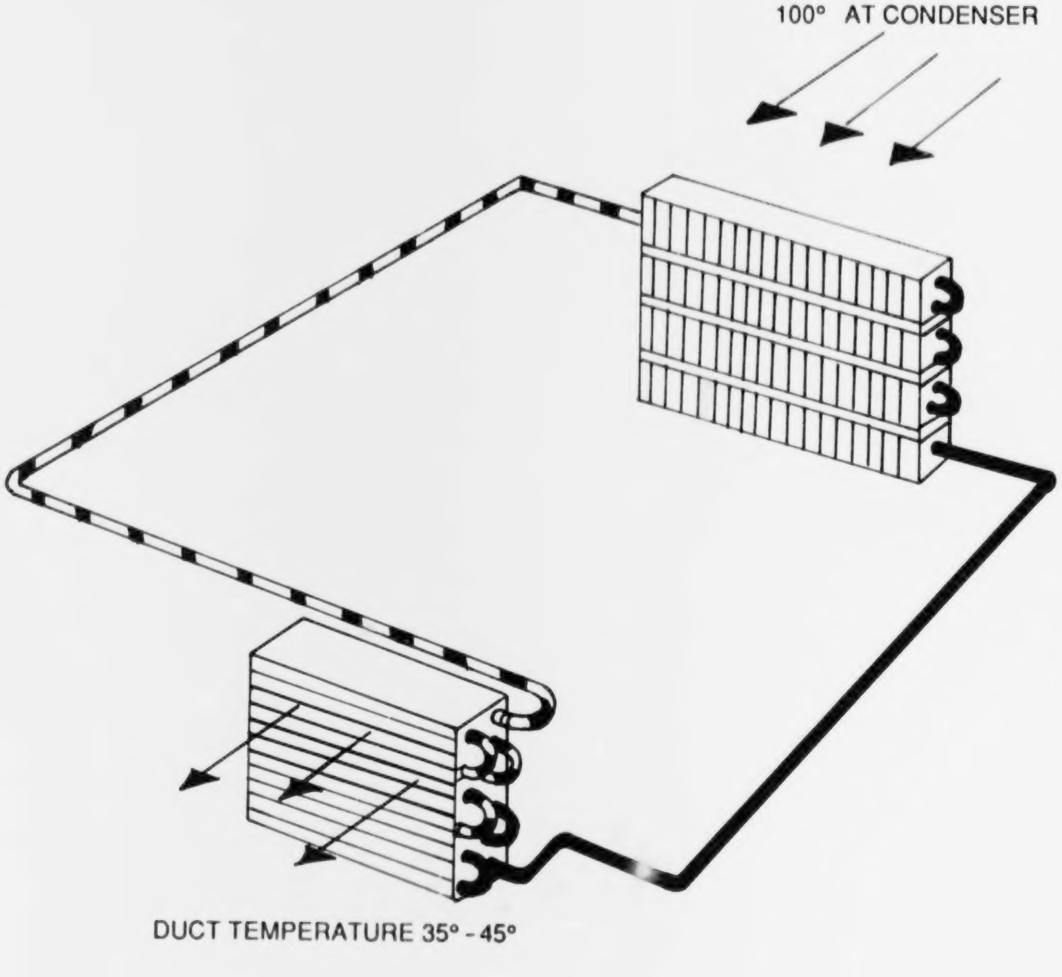
1. During normal operation of a vehicle's air conditioning system, air and moisture are evacuated from the system and replaced with freon.

2. An electric fan blows air across the fins of the evaporator. If the pressure of the freon in the evaporator is 50 psi, the freon will boil at about 50°F (according to the above chart). If the temperature of the air blowing across the evaporator is higher than 50°F, the freon will boil and absorb the heat energy that is in the air. The temperature of the air blowing across the evaporator will then fall to 50°F.

3. Upon reaching the boiling point in the evaporator, the freon changes into a gas and circulates into the condenser. The gaseous freon will enter the condenser at a temperature of around 50°F. The radiator fan blows cool air (less than 50°F) across the fins of the condenser. This air will absorb the heat energy taken from the freon. Thus heat will have been removed from the air blowing across the evaporator and transferred into the air blowing across the condenser. Repetition of this process keeps the vehicle's passenger compartment cool.

(NOTE: Because the freon releases heat energy while in the condenser, the freon will change from a liquid back into a gas.)

(NOTE: The above is a fairly simple description of how the evaporator and condenser function as heat exchangers. In an actual air conditioning system, several complex problems must be solved before heat exchangers can actually function together. These problems will be addressed in later units of this module.)



MODULE: HEATING AND AIR CONDITIONING

PRINCIPLES OF AIR CONDITIONING

Instructions: **Do the following tasks and answer the following questions. Write all responses on this sheet.**

1. Define the terms listed below.

Btu

Change of state

Condensation

Evaporation

Latent heat of condensation

Latent heat of evaporation

Pressure

Vacuum

2. Describe the difference between heat and temperature.

3. List three ways by which heat can be transferred.

4. Describe what causes a substance to undergo a change of state.

5. Describe the process of heat exchange in a basic air conditioning system.

MODULE: HEATING AND AIR CONDITIONING

PRINCIPLES OF AIR CONDITIONING

(ANSWER SHEET)

1. A Btu is a unit of heat measurement based upon the amount of heat required to increase the temperature of one pound of water by 1°F.

   A change of state is a fundamental altering of the arrangement of molecules in a substance as the substance changes from one physical state (solid, liquid, vapor) to another.

   Condensation occurs when vapor changes to liquid as a result of heat loss.

   Evaporation occurs when liquid changes to vapor as a result of an increase in heat.

   The latent heat of condensation is the quantity of heat released while a substance changes from a vapor to a liquid without undergoing a significant change in temperature.

   The latent heat of evaporation is the amount of heat absorbed by vapor during evaporation. This absorption of heat allows a substance to remain at a constant temperature while undergoing evaporation.

   Pressure is force per unit of area, such as pounds per square inch (psi).

   A vacuum is an area in which pressure is below the surrounding atmospheric pressure. Vacuums are measured in inches of Mercury (Hg).

2. Heat is a form of energy that can cause a substance to rise in temperature. Temperature, on the other hand, is a measure of the intensity of heat in a substance at a specific time.

3. Conduction, convection, and radiation

4. A significant increase or decrease in heat can cause a substance to undergo a change of state.

5. An electric fan blows air across the fins of the evaporator. If the temperature of this air is higher than the boiling point of the freon in the evaporator, the freon will boil and absorb the heat energy in the air. The temperature of the air being blown across the evaporator will then fall to the boiling point of the freon. The freon then circulates to the condenser. If the temperature of the air moving across the fins of the condenser is below the boiling point of the freon, then the heat energy in the freon will be transferred to this air. Heat from the air surrounding the evaporator will thus be moved to the air surrounding the condenser.

MODULE: HEATING AND AIR CONDITIONING

UNIT I: PRINCIPLES OF AUTOMOTIVE AIR CONDITIONING

UNIT I TEST

SECTION A. Match the terms below with their appropriate definitions.

____ 1. The changing of a vapor to a liquid as a result of the vapor losing heat.

____ 2. An area in which pressure is below the surrounding atmospheric pressure.

____ 3. The process of transferring heat by circulating liquid or vapor.

____ 4. A process by which heat is transferred through a substance.

____ 5. Energy produced by the movement of molecules in any substance above 0° Kelvin (Absolute zero).

____ 6. The changing of a liquid to a vapor as a result of an increase in heat in the liquid.

____ 7. A process in which heat passes through a substance without increasing its temperature.

a. British thermal unit
b. Condensation
c. Conduction
d. Convection
e. Evaporation
ab. Heat
ac. Radiation
ad. Vacuum

SECTION B. Select the best answer from the five choices listed.

____ 8. The temperature of a substance indicates

a. the amount of heat energy required to bring the substance to that temperature.
b. the rate at which the substance was heated.
c. the intensity of heat in any substance at a specific time.
d. all of the above.
e. none of the above.

____ 9. One Btu represents the amount of energy required to

a. raise the temperature of one pound of water by 1°F.
b. raise the temperature of one gallon of water by 1°F.
c. raise the temperature of one pound of water by 10°F.
d. bring one gallon of water to a boil.
e. do none of the above.

____ 10. Increasing pressure on a liquid's surface will

a. lower the temperature at which the liquid will boil.
b. raise the temperature at which the liquid will boil.
c. raise the amount of heat energy in the liquid without raising the liquid's temperature.
d. lower the amount of heat energy in the liquid without lowering the liquid's temperature.
e. do none of the above.

____ 11. If freon is at 14.7 psi, it will boil at

a. 212°F.
b. 100°F.
c. 0°F.
d. -12°F
e. -22°F.

____ 12. Freon should be handled with care because it

a. is highly toxic.
b. is highly flammable.
c. can eat through clothing and burn human flesh.
d. will explode if exposed to the open air.
e. can instantly freeze human flesh.

____ 13. Freon is a good choice for an air conditioning refrigerant because it

a. is not corrosive to aluminum or steel.
b. is soluble in oil.
c. maintains a predictable relationship between pressure and temperature.
d. has all of the above characteristics.
e. has none of the above characteristics.

SECTION C. Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.

____ 14. In an automotive air conditioning system, the evaporator is a radiator-like device located outside the passenger area.

____ 15. In an automotive air conditioning system, the evaporator has tubes for circulating freon and fins for conducting the flow of heat.

____ 16. The condenser in an automotive air conditioning system is a radiator-like device located within the passenger compartment.

____ 17. In a typical automotive air conditioning system, cool air is produced in a refrigeration unit located outside the passenger compartment.

____ 18. When freon vapor changes from vapor into liquid in the condenser, the air around the condenser is cooled.

____ 19. Pressure within the automotive air conditioning system is usually the same as atmospheric pressure.

____ 20. Heat which is transferred from liquid to vapor during boiling is referred to as the latent heat of evaporation.

(NOTE: The student must obtain a minimum score of _____ on the Unit I Test in order to receive an evaluation for Competencies Gg1-Gg4.)

ANSWERS TO UNIT I TEST

1.	b
2.	ad
3.	d
4.	c
5.	ab
6.	e
7.	ac
8.	c
9.	a
10.	b
11.	e
12.	e
13.	d
14.	f
15.	t
16.	f
17.	f
18.	f
19.	f
20.	t

MODULE: HEATING AND AIR CONDITIONING

UNIT II: AUTOMOTIVE AIR CONDITIONING SYSTEM DESIGN

UNIT OBJECTIVE

After completing this unit, the student should be able to identify basic air conditioning components and the manner in which they function during the refrigeration cycle. The student will demonstrate mastery of the material by achieving a score of _____ on the unit test.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1. I. Identify terms and definitions associated with the automotive air conditioning system (Competencies Gg1-Gg4, Unit II Test).

II. Identify the five basic operational phases of an automotive air conditioning system (Competencies Gg1-Gg4, Unit II Test).

III. Identify the components of an automotive air conditioning system (Competencies Gg1-Gg4, Unit II Test).

Lesson 2. I. Identify various expansion valve system designs (Competencies Gg1-Gg4, Unit II Test).

II. Identify various fixed-orifice system designs (Competencies Gg1-Gg4, Unit II Test).

III. Identify various controls found in automotive air conditioning systems (Competencies Gg1-Gg4, Unit II Test).

ASE TASKS COVERED IN THIS UNIT

I. Only material that is preliminary to ASE tasks appears in this unit; therefore, no ASE tasks are covered directly.

MODULE: HEATING AND AIR CONDITIONING

UNIT II: AUTOMOTIVE AIR CONDITIONING SYSTEM DESIGN

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

   1. Lesson 1: COMPONENTS OF THE AUTOMOTIVE AIR CONDITIONING SYSTEM AND HOW THEY FUNCTION

      a. Information outline

   2. Lesson 2: TYPICAL AIR CONDITIONING SYSTEM DESIGNS

      a. Information outline

      b. Assignment sheet

         AS1-L2-UII: Components of the Automotive Air Conditioning System

E. Unit test

F. Answers to unit test

REFERENCES

Carter Carburetor Division, ACF Industries, Inc. Automotive Air Conditioning Theory and Practice.

Mitchell Information Services, Inc. Heating and Air Conditioning Systems. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1987.

Mitchell International, Inc. Automotive Air Conditioning Basic Service Training Manual. 21st ed. San Diego, CA: Mitchell International Inc., 1988.

Mitchell Manuals, Inc. 1984 Edition Automotive Air Conditioning Basic Service Training Manual. San Diego, CA: Mitchell Manuals, Inc., 1984.

Murray Corporation. Dealer Education Program Temperature Control Clinic Workbook. Cockeysville, MD: Murray Corporation, 1988.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

   1. Students should do AS1-L2-UII before taking the Unit II Test.

B. Suggested audio-visual material from The Media Center, State Fair Community College, Sedalia, Mo.

   1. Operation of Orifice Tube Air Conditioning System (AM-86-312), 1986.

MODULE : HEATING AND AIR CONDITIONING

UNIT II: AUTOMOTIVE AIR CONDITIONING SYSTEM DESIGN

LESSON 1: COMPONENTS OF THE AUTOMOTIVE AIR CONDITIONING SYSTEM AND HOW THEY FUNCTION

I Terms and definitions

- A. Accumulator--A receiver-drier device located in the low side of the automotive air conditioning system. The accumulator stores freon and separates liquid oil and freon from vapor. The accumulator also absorbs moisture in the air conditioning system.
- B. Axial compressor--A compressor in which the pistons move along the rotating center line of the shaft.
- C. Capillary tube--A tube that connects the remote temperature sensing bulb with an expansion valve or thermostatic switch.
- D. Clutch--An electromechanical device that couples the drive pulley to the compressor shaft.
- E. Clutch cycling switch--A switch that engages or disengages the compressor clutch in relation to evaporator pressure or temperature.
- F. Compressor--Pump that circulates freon through the air conditioning system. The compressor also raises the pressure and temperature of freon.
- G. Compressor cutout--Device that prevents compressor operation in the following situations: when the system is low on freon; when the power steering pump exceeds relief pressure; when the throttle is wide open; and when system pressure is excessive.
- H. Compressor discharge switch--Device that disengages compressor clutch when freon pressure becomes too low.
- I. Cycling-clutch orifice tube system--A system that uses an accumulator and an orifice tube instead of an expansion valve.
- J. Cycling-clutch orifice tube--A tube with a metered passage through the center. The orifice tube is located between the condenser and the evaporator in the high-pressure line.
- K. Desiccant--A chemical agent used to absorb moisture from freon in air conditioning systems.
- L. Drier--A device containing desiccant. The drier is usually a canister that serves multiple functions.
- M. Equalizer line--A line used to transfer sensor pressure from one side of the expansion valve to some other point on the valve. The line serves to modify the expansion valve position.
- N. Evaporator pressure regulator valve--A valve that regulates pressure in the evaporator. The valve is located in the evaporator outlet to prevent liquid freon carry-over.
- O. Evaporator temperature regulator--A device that regulates evaporator outlet volume on the basis of outlet temperature. The regulator prevents evaporator carry-over.
- P. Expansion valve--A device that regulates freon flow into the evaporator inlet on the basis of temperature and pressure.

Q. Fixed-orifice tube--Same as cycling-clutch orifice tube.

R. Head pressure--Compressor discharge pressure.

S. High side--Area of the air conditioning system between the compressor discharge and the expansion valve or orifice tube.

T. Low side--Area of the air conditioning system between the expansion valve and the suction side of the compressor.

U. Magnetic clutch--An electromagnetic device used to couple the drive belt to the compressor shaft.

V. Oil bleed--Line or passage that ensures a continuous oil vapor supply to the compressor. The line is located close to the EPR or expansion valve.

W. Orifice tube--Same as cycling-clutch orifice tube.

X. Pressure sensing switch--Switch that turns the compressor on and off in cycling-clutch systems.

Y. Receiver-drier--A device that acts as an accumulator for excess freon. The receiver-drier also removes moisture from freon.

Z. Refrigeration oil--A special oil that eliminates contaminants and tars from freon.

AA. Thermostatic switch--Cycles the compressor clutch according to evaporator temperature.

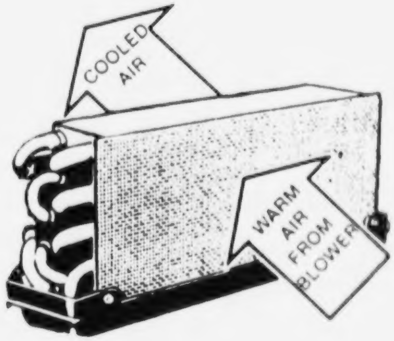
AB. Thermostatic expansion valve--Regulates freon flow into the evaporator inlet according to evaporator temperature.

II. Five operational phases of an air conditioning system

A. Evaporation phase

1. The evaporator is a series of coils mounted in groups of fins. The evaporator is located in the air stream of a blower unit. As freon circulates through the coils, heat from inside the vehicle is transferred from the air to the freon.

2. During the refrigeration cycle, low-pressure liquid freon flows into the evaporator coil. (The low pressure reduces the freon's boiling point.) Heat from air blown across the coils causes the freon to boil and turn to vapor. By changing from a liquid to a vapor, the freon absorbs heat in the air around the evaporator. The freon exits the evaporator as a warm gas.

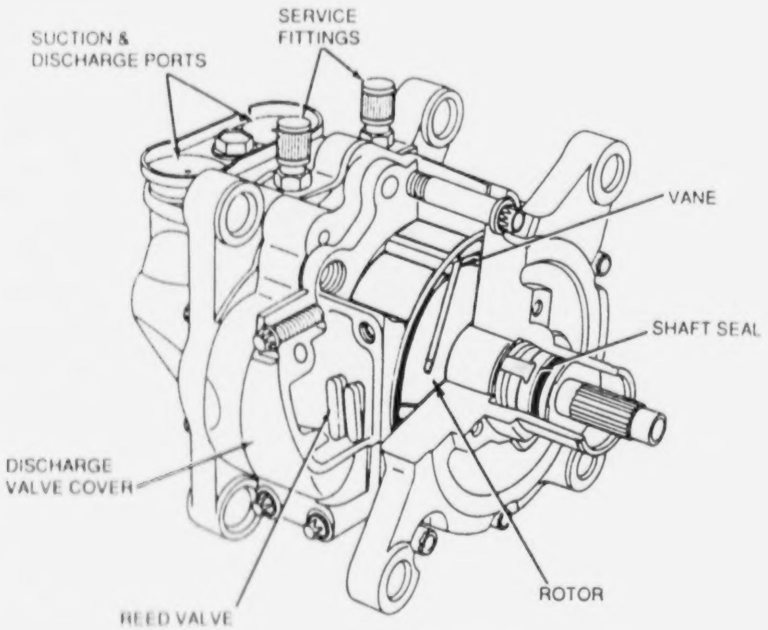


B. Compression phase

1. The compressor is a simple pump that changes low-pressure, low-temperature vapor to a high-pressure, high-temperature vapor.

2. During the refrigeration cycle, warm freon gas enters the compressor inlet. Freon then exits the discharge outlet as a high-pressure, high-temperature gas. The high pressure raises the freon's boiling point and increases the difference in temperature between the freon and the outside air.

3. In a magnetic clutch assembly, a control circuit supplies electrical current to a stationary wound coil located behind a metal flex plate. The flex plate is attached to the compressor drive shaft. The magnetic field created by the coil pulls the flex plate into contact with the drive pulley. The flex plate and drive pulley are thereby locked together. The engine drive belt turns the compressor shaft.



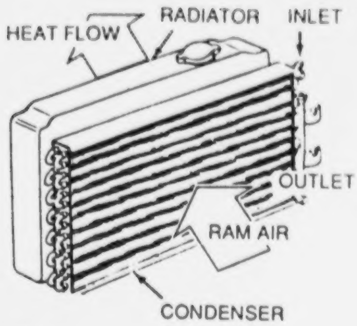
CUTAWAY VIEW OF YORK ROTARY VANE COMPRESSOR

Courtesy of Mitchell Information Services, Inc

C. Condensation phase

1. The condenser consists of a series of coils mounted in a group of fins. Freon circulates through the coils. Cooling fan action and the forward movement of the vehicle cause the outside air to pass over the coils.

2. After undergoing an increase in temperature and pressure in the compressor, the freon enters the condenser as a high-pressure, high-temperature gas. The much cooler outside air absorbs the high heat content of the freon, thus reducing the freon's temperature. Remember that, at this stage, the boiling point of the freon is very high. The drop in temperature, therefore, causes the freon to condense into a warm liquid at high pressure.



D. Drying and storage phase

1. The receiver-drier or accumulator can be located either after the condenser or before the compressor, depending upon the system design. In either case, it functions in the same manner. As freon enters the receiver-drier or accumulator, it passes through a sack of desiccant, a water-absorbing chemical.

2. An accumulator also allows the freon to finish evaporating; the accumulator holds the freon until the system can accept it. The accumulator also meters a constant supply of refrigerant oil to the compressor.

3. Water must be removed from air conditioning systems because of the reasons listed below.

    a. The boiling point of water is beyond the pressure/temperature range of freon. Water, therefore, occupies space within the system without assisting in heat transfer.

    b. Water is corrosive to the system.

    c. Water tends to freeze in the expansion/orifice tube, blocking the passage of freon.

E. Expansion phase

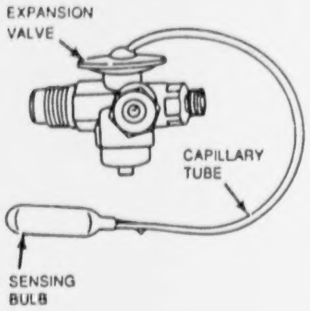
1. In the expansion phase, either an expansion valve or orifice tube changes freon from a high-pressure liquid to a low-pressure liquid. While passing through either the valve or tube, freon undergoes a drop in differential pressure and in temperature. The freon, therefore, achieves a lower boiling point. The freon then flows into the evaporator where the heat in the surrounding air causes the freon to boil.

2. An expansion valve consists of a filter screen, a meter orifice, and a pressure or temperature control. The valve serves the three functions listed below.

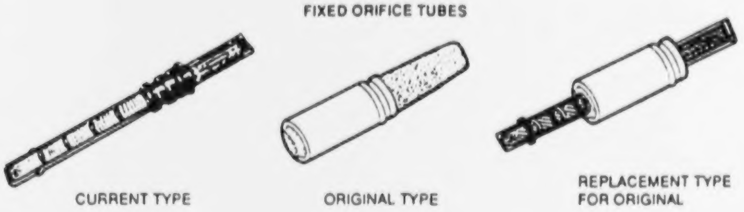
    a. The valve reduces the pressure of the freon through expansion.

    b. The valve regulates the rate of freon flow according to evaporator temperature or pressure.

    c. The valve uses a filter screen to trap any debris or ice in the freon.

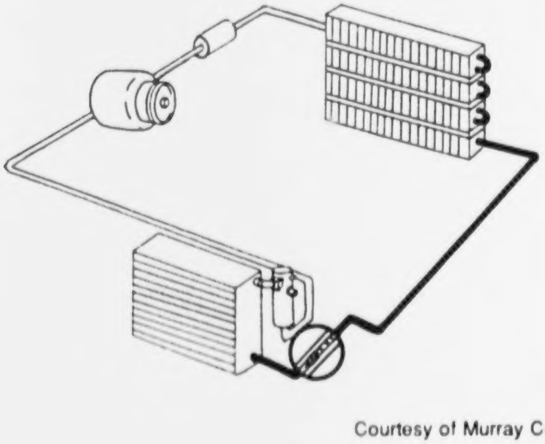

EXPANSION VALVE
CAPILLARY TUBE
SENSING BULB

3. Since the early 1980's, fixed-orifice tubes have replaced expansion valves in many automotive air conditioning systems. The fixed-orifice tube works in the same manner and serves the same functions as an expansion valve. In an orifice tube system, however, the rate of freon flow is determined by the pressure of the system at a point before the orifice.


FIXED ORIFICE TUBES
CURRENT TYPE
ORIGINAL TYPE
REPLACEMENT TYPE FOR ORIGINAL

Courtesy of Murray Corporation

4. During the refrigeration cycle, freon (in the form of a high-pressure liquid) passes into the expansion valve inlet through a filter screen.

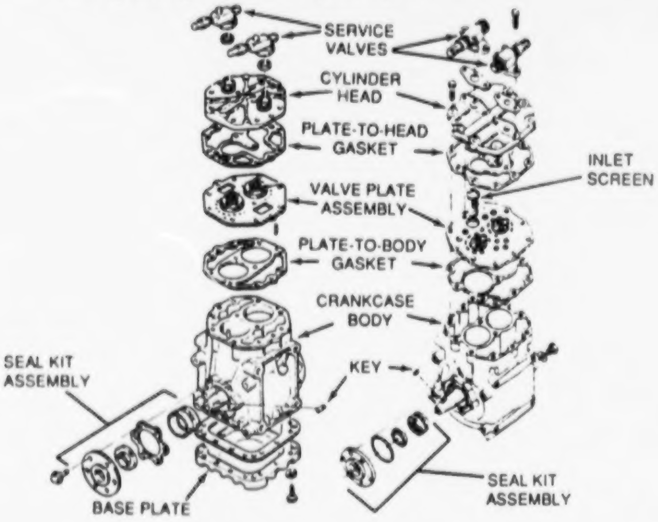


Courtesy of Murray Corporation

III. Automotive air conditioning components

A. Types of compressors and their components

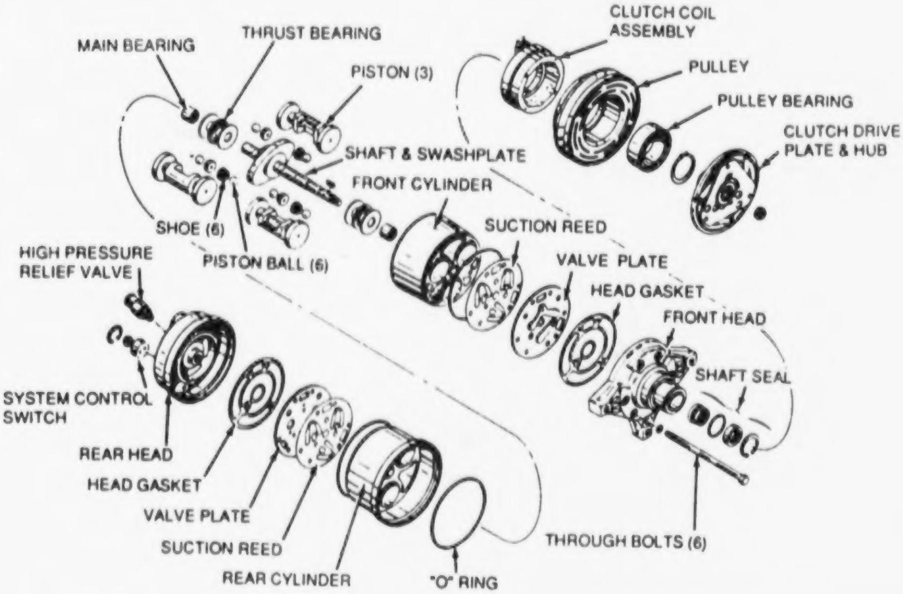
1. In the V- or in-line reciprocating piston compressor, the pistons move at a 90-degree angle to the crankshaft center line. Either an internal pump or centrifugal force, generated by the crankshaft, provides lubrication. Reed plate valves provide inlet and exhaust valving. A specially designed seal keeps freon and oil from leaking along the rotating compressor shaft.


SERVICE VALVES
CYLINDER HEAD
PLATE-TO-HEAD GASKET
INLET SCREEN
VALVE PLATE ASSEMBLY
PLATE-TO-BODY GASKET
CRANKCASE BODY
SEAL KIT ASSEMBLY
KEY
BASE PLATE
SEAL KIT ASSEMBLY

YORK COMPRESSOR **TECUMSEH COMPRESSOR**

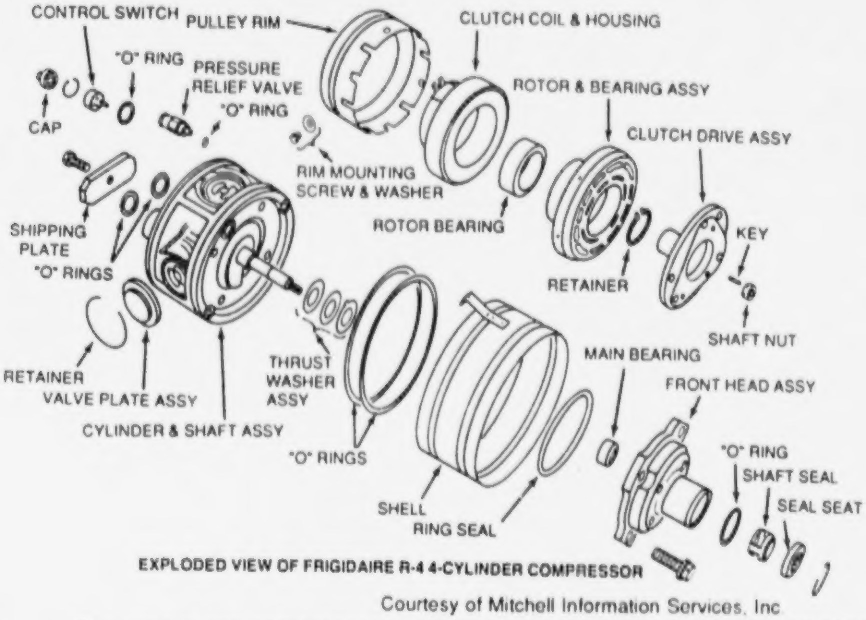
Courtesy of Mitchell Information Services, Inc.

2. In the axial-flow compressor, the reciprocating motion of the axle swatch plate moves the pistons. Normally three or four pistons are arranged around the compressor shaft. Reed plate valves provide valving. An internal oil pump provides lubrication.


CLUTCH COIL ASSEMBLY
MAIN BEARING
THRUST BEARING
PISTON (3)
PULLEY
PULLEY BEARING
CLUTCH DRIVE PLATE & HUB
SHAFT & SWASHPLATE
FRONT CYLINDER
SHOE (6)
SUCTION REED
HIGH PRESSURE RELIEF VALVE
PISTON BALL (6)
VALVE PLATE
HEAD GASKET
FRONT HEAD
SHAFT SEAL
SYSTEM CONTROL SWITCH
REAR HEAD
HEAD GASKET
VALVE PLATE
SUCTION REED
REAR CYLINDER
"O" RING
THROUGH BOLTS (6)

Courtesy of Mitchell Information Services, Inc.

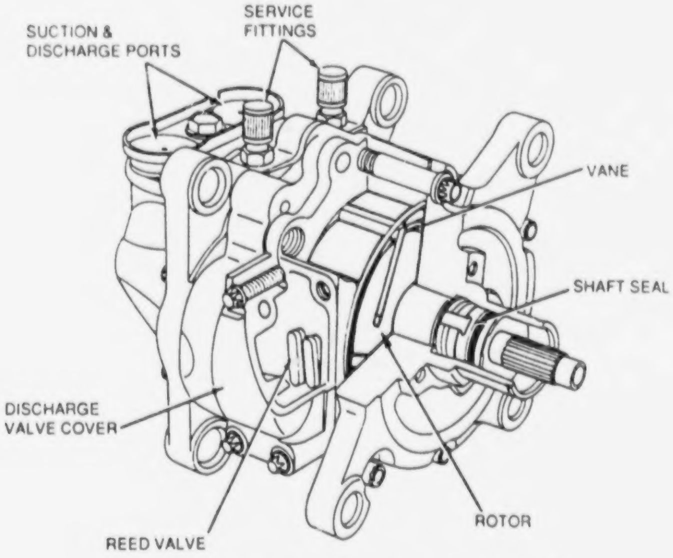
3. Cylinders in the radial-cylinder compressor radiate from the center line of the compressor shaft. Reed plates provide valving. Radial-cylinder compressors do not always use pressure lubrication.


CONTROL SWITCH
PULLEY RIM
CLUTCH COIL & HOUSING
"O" RING
PRESSURE RELIEF VALVE
ROTOR & BEARING ASSY
"O" RING
CAP
CLUTCH DRIVE ASSY
RIM MOUNTING SCREW & WASHER
ROTOR BEARING
SHIPPING PLATE
KEY
"O" RINGS
RETAINER
SHAFT NUT
MAIN BEARING
THRUST WASHER ASSY
RETAINER
VALVE PLATE ASSY
FRONT HEAD ASSY
CYLINDER & SHAFT ASSY
"O" RING
"O" RINGS
SHAFT SEAL
SEAL SEAT
SHELL
RING SEAL

EXPLODED VIEW OF FRIGIDAIRE R-4 4-CYLINDER COMPRESSOR

Courtesy of Mitchell Information Services, Inc

4. The vane-pump compressor has no pistons. An eccentrically shaped chamber and a rotor with several sliding vanes provide pump action.


SUCTION & DISCHARGE PORTS
SERVICE FITTINGS
VANE
SHAFT SEAL
DISCHARGE VALVE COVER
ROTOR
REED VALVE

CUTAWAY VIEW OF YORK ROTARY VANE COMPRESSOR

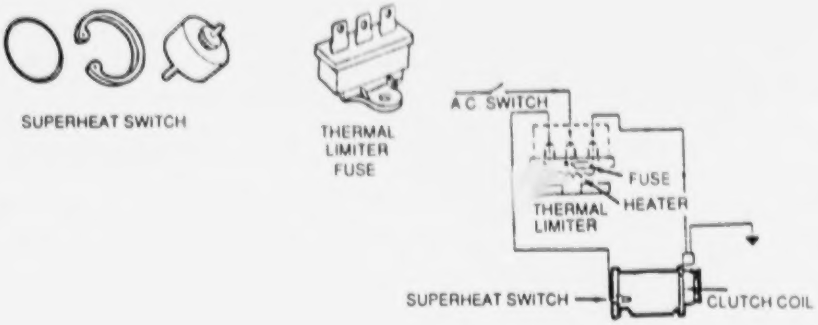
Courtesy of Mitchell Information Services, Inc

5. In the future, most air conditioning systems will use compressors that constantly run. The new systems will use either the variable swash plate style or the serpentine style compressor.

6. Compressor protective devices

a. In order to regulate evaporator pressure, the suction side of some Chrysler compressors have a temperature-activated or pressure-activated control valve. This valve limits freon passage if there is a risk of liquid freon entering the compressor inlet.

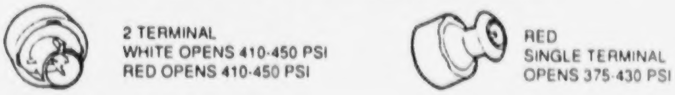
b. When freon is too low to sustain cooling, an overheat switch in the compressor blows a thermal fuse, thus preventing clutch engagement.


SUPERHEAT SWITCH
THERMAL LIMITER FUSE
A C SWITCH
FUSE
HEATER
THERMAL LIMITER
SUPERHEAT SWITCH
CLUTCH COIL

Courtesy of Murray Corporation

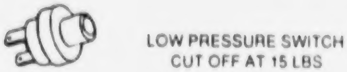
c. A pressure cutout switch will stop current flow to the magnetic clutch if system pressure becomes too high or too low. The cutout switch will open and prevent compressor clutch engagement. The high-pressure cutout switch may be located in the rear head of the compressor. The switch may also be located on the muffler assembly in the high-pressure line between the compressor and condenser. The cutout switch is in the ground circuit of the compressor clutch circuit. A high-pressure failure can be caused by failure of the cooling fan or a restriction of air flow across the fins of the condenser.

d. On most General Motors front-wheel-drive vehicles, a high-pressure safety switch is used to shut the compressor clutch circuit off if system pressure exceeds 375-430 psi. The switch is located in either the rear of the compressor or in the high-pressure line.


2 TERMINAL
WHITE OPENS 410-450 PSI
RED OPENS 410-450 PSI
RED
SINGLE TERMINAL
OPENS 375-430 PSI

Courtesy of Murray Corporation

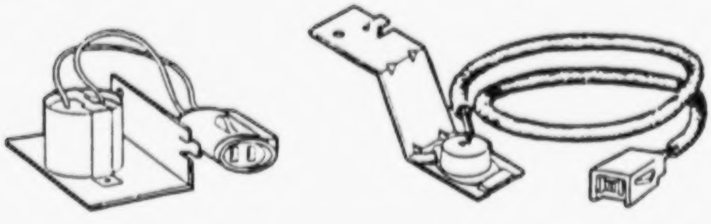
e. Most manufacturers use a low-pressure cutout switch to open the compressor clutch circuit if freon charge is lost. The cutout switch is located just before the expansion valve or orifice tube.


LOW PRESSURE SWITCH
CUT OFF AT 15 LBS

Courtesy of Murray Corporation

f. The pressure-relief valve in the compressor will vent excess freon into the atmosphere if system pressure becomes excessively high.

g. An ambient temperature cutout prevents compressor clutch engagement when the ambient (outside) temperature falls below 50°F.

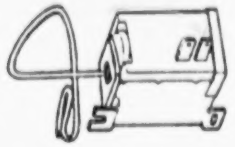


AMBIENT TEMPERATURE SWITCHES

Courtesy of Murray Corporation

7. Compressor cycling controls

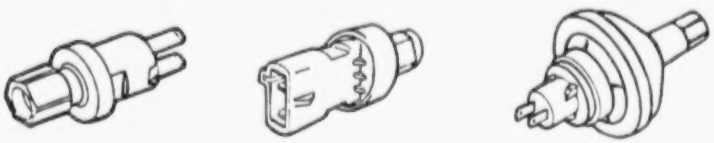
a. On some systems a thermostatic switch controls cycling according to evaporator temperature. A capillary tube measures the temperature of the evaporator coil. The gas in the capillary tube expands or contracts according to evaporator temperature. When the gas in the capillary tube expands, the diaphragm switch will close. The closing of the diaphragm switch completes the compressor clutch circuit, which then activates the compressor's magnetic clutch.



THERMOSTATIC CLUTCH CYCLING SWITCH

Courtesy of Murray Corporation

b. On other systems, a pressure-sensing switch is located in the outlet portion of the evaporator. This switch cycles the compressor clutch according to evaporator pressure. Because temperature and pressure are related in air conditioning systems, the pressure sensing switch also regulates evaporator temperature.



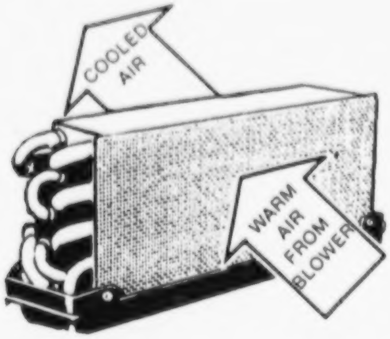
CLUTCH CYCLING PRESSURE SWITCH

Courtesy of Murray Corporation

B. Components of evaporation units

1. An evaporator coil consists of a set of interconnected tubes, which are attached to thin aluminum fins. These fins increase the area of heat conduction.

2. A tray and discharge hose mounted near the bottom evaporator drains away moisture that collects on the coil.

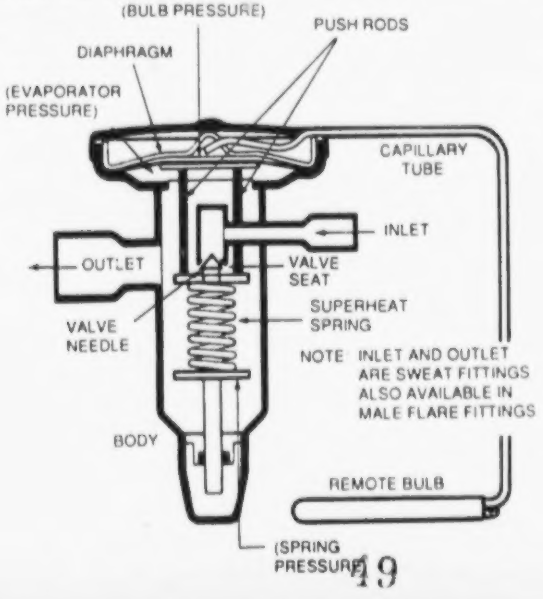

COOLED AIR
WARM AIR FROM BLOWER

3. A thermostatic expansion valve controls freon flow within the evaporator. This valve (a metering valve) makes use of a temperature-sensing bulb and an equalization control bypass tube.

    a. The orifice (metering valve) meters the pressure of the incoming liquid freon from high to low by moving a valve across the metering orifice.

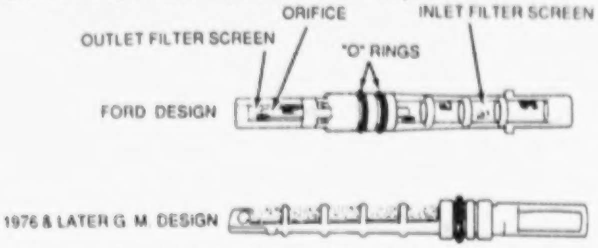
    b. Evaporator temperature expands or contracts a temperature-sensing bulb within the valve. (Temperature-sensitive gas within the bulb causes the expansion and contraction.) This expansion and contraction exerts varying amounts of pressure on the expansion valve diaphragm through a capillary tube. The diaphragm pushes open the valve allowing freon to flow through the metering orifice.

    c. Pressure of the expansion valve outlet counters the action of the temperature-sensing diaphragm. Therefore, modulation of the valve movement is balanced. The equalization may be internal or external to the valve. A return valve spring moves the valve toward the closed position when the temperature-sensing diaphragm is relaxed (i.e. when evaporator temperature is low).


(BULB PRESSURE)
PUSH RODS
DIAPHRAGM
(EVAPORATOR PRESSURE)
CAPILLARY TUBE
INLET
OUTLET
VALVE SEAT
SUPERHEAT SPRING
VALVE NEEDLE
BODY
REMOTE BULB
(SPRING PRESSURE)

NOTE INLET AND OUTLET ARE SWEAT FITTINGS ALSO AVAILABLE IN MALE FLARE FITTINGS

4. As was stated earlier, many automotive air conditioning systems now use a fixed-orifice tube instead of an expansion valve. The fixed-orifice tube is located in the same place in the system as the expansion valve. The orifice tube meters the freon flow according to the (fixed) size of the orifice opening and the amount of pressure exerted against the orifice by the compressor. A filter screen eliminates debris from the freon, preventing blockage of the small orifice. As the compressor cycles on and off (according to evaporator pressure or temperature), there is a change in the rate at which freon flows into the evaporator.

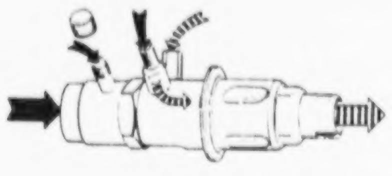

ORIFICE
INLET FILTER SCREEN
OUTLET FILTER SCREEN
"O" RINGS
FORD DESIGN
1976 & LATER G. M. DESIGN

EXPANSION TUBES USED IN CYCLING CLUTCH SYSTEM

Courtesy of Mitchell Information Services, Inc.

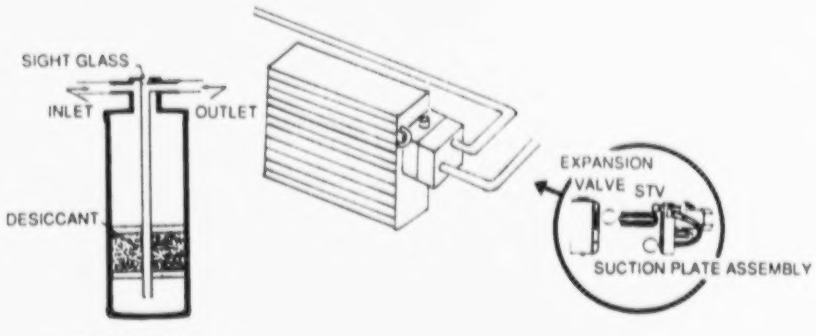
5. In some air conditioning systems, additional valves are used to enhance the efficiency and the operation of the expansion valve. These additional valves are activated either by pressure or a combination of temperature and pressure.

   a. A pressure-activated valve, for example, keeps the evaporator outlet pressure between 29 and 31 psi. This constant level of pressure ensures that the evaporator does not freeze up and that liquid freon does not flow into the compressor inlet line.



Courtesy of Mitchell Information Services, Inc.

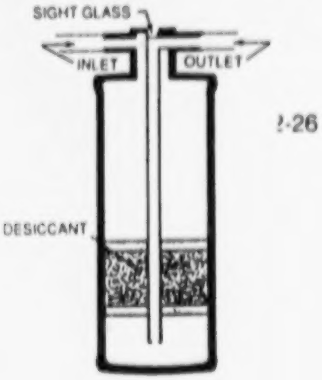
   b. Combination temperature/pressure valves combine the expansion valve and pressure-activated valve into one unit. The rate of freon flow at the evaporator inlet modulates with outlet pressure to create balanced evaporator activity.


SIGHT GLASS
INLET
OUTLET
DESICCANT
RECEIVER-DRIER
EXPANSION VALVE
STV
SUCTION PLATE ASSEMBLY

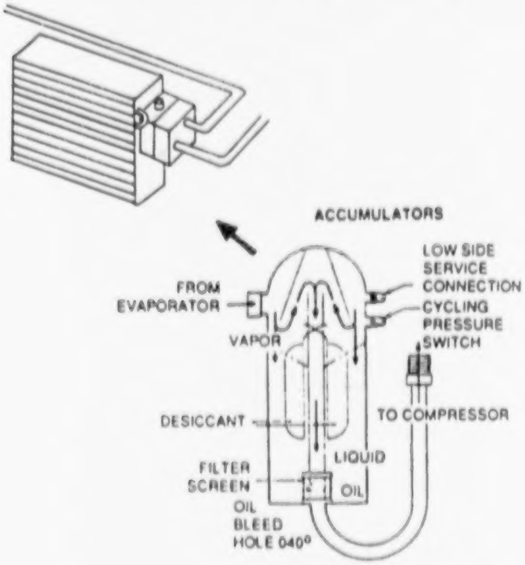
C. Receiver-drier/accumulator units

1. The receiver-drier is located midway between the condenser outlet and the expansion valve. Automotive air conditioning systems can use either standard receiver-driers (which are sealed canisters with no valves) or receiver-driers with valves in the receiver (VIR). Both types of driers store freon, absorb moisture, and filter debris.

   (NOTE: Some receiver-driers have a sight glass to make servicing easier.)


SIGHT GLASS
INLET
OUTLET
2-26
DESICCANT

2. The accumulator is located at the outlet of the evaporator. The accumulator stores freon while freon finishes evaporating and removes the moisture from it. The accumulator also filters freon and meters the flow of oil to the compressor.


ACCUMULATORS
FROM EVAPORATOR
LOW SIDE SERVICE CONNECTION
CYCLING PRESSURE SWITCH
VAPOR
DESICCANT
TO COMPRESSOR
LIQUID
FILTER SCREEN
OIL
OIL BLEED HOLE 040°

Courtesy of Murray Corporation

MODULE: HEATING AND AIR CONDITIONING

UNIT II: AUTOMOTIVE AIR CONDITIONING SYSTEM DESIGN

LESSON 2: TYPICAL AIR CONDITIONING SYSTEM DESIGNS

I. Expansion valve system designs

   A. Components of the basic five-part thermostatic system

      1. Compressor

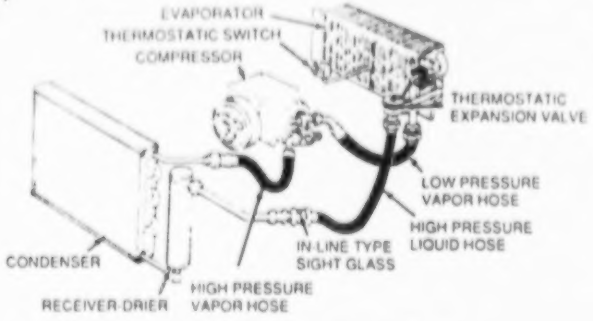
      2. Condenser

      3. Receiver-drier

      4. Expansion valve

      5. Evaporator

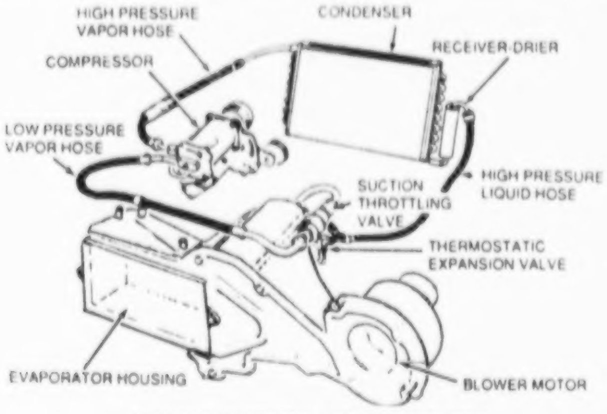
   (NOTE: In basic five-part thermostatic systems, a thermostatic switch controls cycling of the compressor.)


EVAPORATOR
THERMOSTATIC SWITCH
COMPRESSOR
THERMOSTATIC EXPANSION VALVE
LOW PRESSURE VAPOR HOSE
HIGH PRESSURE LIQUID HOSE
IN-LINE TYPE SIGHT GLASS
CONDENSER
RECEIVER-DRIER
HIGH PRESSURE VAPOR HOSE

THERMOSTATIC SWITCH TYPE CYCLING CLUTCH A/C SYSTEM

Courtesy of Mitchell Information Services, Inc.

   B. Components in the suction throttling valve system (pressure type) are the same as those in the thermostatic system except for the addition of an STV valve. This valve maintains precise evaporator pressure. A POA (pilot-operated-absolute) valve is similar in appearance and operation to the STV. Both valves are located in the evaporator outlet line.

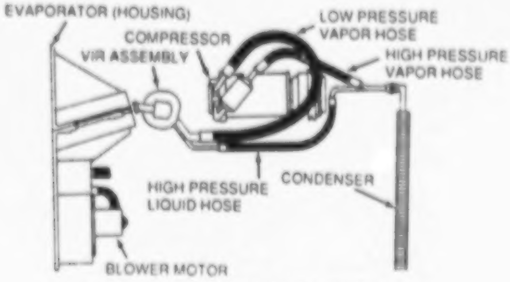

HIGH PRESSURE VAPOR HOSE
CONDENSER
RECEIVER-DRIER
COMPRESSOR
LOW PRESSURE VAPOR HOSE
SUCTION THROTTLING VALVE
HIGH PRESSURE LIQUID HOSE
THERMOSTATIC EXPANSION VALVE
EVAPORATOR HOUSING
BLOWER MOTOR

SUCTION THROTTLING VALVE TYPE A/C SYSTEM

Courtesy of Mitchell Information Services, Inc.

C. Components in the evaporator pressure regulator system (pressure type) are the same as those in the thermostatic system except for the addition of the EPR valve (which is located in the compressor inlet). The EPR maintains precise evaporator outlet pressure. The EPR valve was used on Chrysler vehicles equipped with air conditioning during the 1970's. The valve was located in the back of the compressor.

D. Components in the VIR (valves-in-receiver) system remain the same as those in the thermostatic system with the exception of the expansion valve and receiver-drier. These two components are combined into a single unit. Some VIR systems use an internal POA or EPR valve as well.

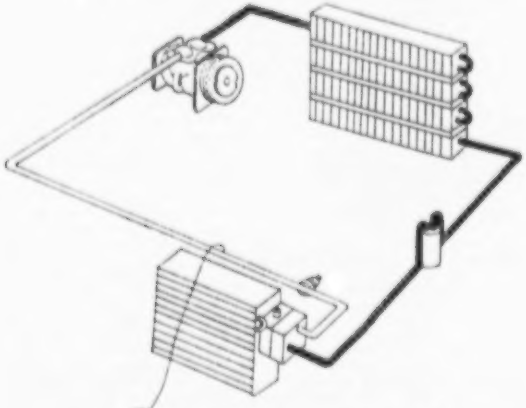

EVAPORATOR (HOUSING)
COMPRESSOR
VIR ASSEMBLY
LOW PRESSURE VAPOR HOSE
HIGH PRESSURE VAPOR HOSE
HIGH PRESSURE LIQUID HOSE
CONDENSER
BLOWER MOTOR

VALVES-IN-RECEIVER TYPE A/C SYSTEM

Courtesy of Mitchell Information Services, Inc.

E. Components in the combination valve (common manifold) system are the same as those in the thermostatic system. In the combination valve system, however, the expansion valve controls the rate of freon flow in both the inlet and exhaust.

F. Components in the cycling-clutch thermostatic system are the same as those in the thermostatic system except for the addition of a pressure cycling switch. The pressure cycling switch cycles the clutch to maintain evaporator pressure within precise limits.



Courtesy of Murray Corporation

II. Fixed-orifice-tube system designs

A. Basic components of the five-part, fixed-orifice, cycling-clutch system

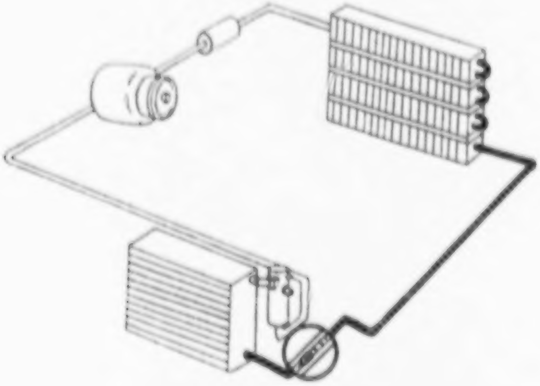
1. Compressor
2. Condenser
3. Orifice tube
4. Evaporator
5. Accumulator

(NOTE: In the five-part, fixed-orifice, cycling-clutch system, cycling of the compressor is controlled by a pressure switch located in the outlet side of the evaporator and by a heater/air conditioner control switch located on the dash. A plenum-blend door varies temperature by mixing warm and cold air. The door is operated by a cable attached to the temperature-control lever on the dash.)

B. Except for the addition of the orifice tube, all components in the fixed-orifice tube, cycling-clutch system are the same as those in the basic five-part thermostatic system. The thermostatic switch still controls the compressor clutch circuit. Compressor clutch cycling is based upon evaporator pressure.

(NOTE: The temperature control switch on the dashboard controls the thermostatic switch.)

C. All the components in the constant-run system (a system in which the compressor is constantly engaged) are the same as those in the fixed-orifice-tube system with the exception of the cycling pressure switch. The constant-run system does not use the cycling pressure switch. Freon flow in the constant-run system is controlled by an expansion valve in the evaporator line along with an additional valve in the evaporator outlet line. The purpose of the additional valve in the evaporator outlet line is to ensure total evaporation of the freon before it is returned to the compressor.



Courtesy of Murray Corporation

III. Additional controls

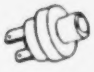
A. Augmented clutch cycle controls

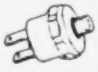
1. Disengagement (interrupt) controls

a. A low-pressure cutout switch opens the clutch circuit when freon pressure becomes too low.

b. On Chrysler systems, two types of low-pressure switches are used. Type one is mounted on a block-type expansion valve and monitors the low-pressure side of the system. If pressure on the low-pressure side drops below 14 psi, the switch opens and prevents the compressor clutch from engaging. Type two is mounted on the receiver-drier and monitors pressure on the high side of the system. If pressure on the high side drops below 35 psi, the switch opens and prevents the compressor clutch from engaging.

(NOTE: Both valves look very similar, but are not interchangeable.)



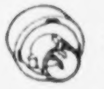


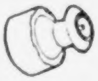
Courtesy of Murray Corporation

c. On General Motors front-wheel-drive vehicles, the compressor is cycled off if system pressure exceeds 375-440 psi. This system uses a pressure switch in the ground circuit of the compressor clutch.

(NOTE: Excessively high pressure in the air conditioning system can be caused by a failure of the cooling fan or a restriction of air flow through the condenser.)

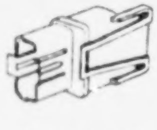
d. A high-pressure cutout switch opens the clutch circuit when system pressure becomes excessive due to overcharging.





Courtesy of Murray Corporation

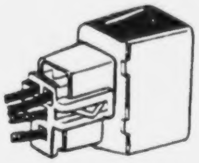
e. A time-delay relay switch keeps the air conditioning clutch circuit open for a period of 10 to 30 seconds after initial engine start-up. The engine idle will stabilize during this 10 to 30 seconds.



Courtesy of Murray Corporation

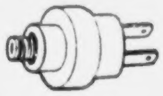
f. Some automobile manufacturers use some type of time delay relay to prevent the compressor clutch from engaging during periods of low rpm or destabilized engine operation.

g. A power-brake, time-delay relay switch interrupts the clutch circuit for 3 to 5 seconds after the brakes are applied. This interruption prevents engine stalling. This unit is used on Ford's front-wheel-drive vehicles with automatic transmissions. The relay is often mounted behind the glove box.



Courtesy of Murray Corporation

h. The power steering cutout relay interrupts the clutch circuit when pressure in the power steering pump becomes excessive due to close-quarter maneuvering. This interruption prevents engine stalling. The relay is used on both General Motors and Ford vehicles; it can be mounted in the high-pressure line or in the steering box.

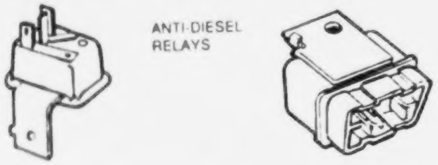


Courtesy of Murray Corporation

i. The wide-open-throttle switch (WOT) interrupts the clutch circuit when the throttle is pushed to within 10% of its maximum opening. This interruption allows the engine to provide more horsepower to the drive train. The WOT switch is used on most front-wheel-drive vehicles.

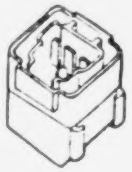
2. Clutch engagement controls

a. The antidiesel relay switch energizes the air conditioning clutch circuit for 3 to 5 seconds after the key is turned off. The additional load placed on the engine prevents engine run-on.



Courtesy of Murray Corporation

b. Some vehicles that are equipped with an engine-control computer use a constant-run relay switch to keep the air conditioning clutch circuit engaged when the vehicle rapidly decelerates. The function of the constant-run relay is to facilitate smooth idling and prevent the vehicle from overheating. Some General Motors vehicles use this relay, which is controlled by the Electronic Control Module (ECM).



Courtesy of Murray Corporation

B. Cooling system controls

1. Fan clutch control

   a. In fans that use a thermostatic clutch, an internal metal strip controls fan speed.

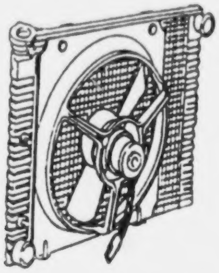
   b. Torque-operated (viscous) fans maintain the same rpm even though there is variation in the engine rpm. As engine speed increases, viscous coupling in the clutch assembly slips.

   c. Thermostatic fans are controlled by the temperature of the air coming out of the radiator. When the air is cool or cold, the fan clutch is allowed to freewheel. When the air is hot, the viscous coupling locks up the fan and shaft, and, therefore, more air is drawn through the radiator.

   d. A fan clutch should be replaced if the blades move more than $^{1}/4$ inch; if fluid leaks from the viscous coupling; or if the vehicle overheats in stop-and-go traffic.

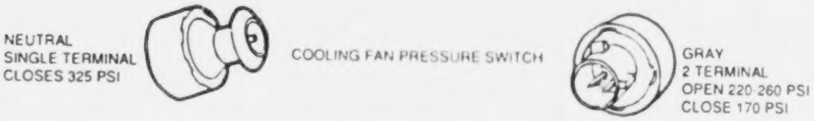
2. Electric cooling fan

   a. A temperature-controlled fan uses a temperature-sensitive switch to complete the fan circuit when engine coolant temperature rises to a preset level. The fan may run after the engine is shut off.



Courtesy of Chrysler Motors Corporation

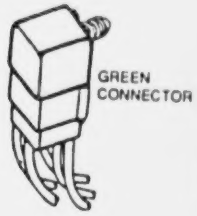
   b. Some electric cooling fans use a pressure- sensitive switch to measure the air conditioning compressor outlet pressure. When pressure rises to a preset level, the switch completes the cooling fan circuit. Some GM and import vehicles use this switch. On GM vehicles, the switch usually turns on the cooling fan when the air conditioner's high-side pressure reaches 325 pounds.



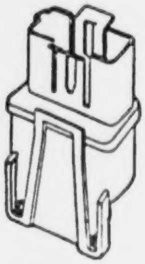
Courtesy of Murray Corporation

c. The engine cooling fan can also be controlled by a relay that energizes the fan circuit whenever the air conditioning is turned on. This method is very common on late-model vehicles.

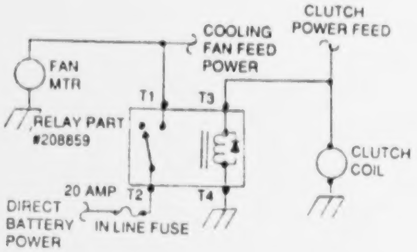
(NOTE: Vehicles that use a fan control that is activated by air conditioning operation also use a fan control that is activated by coolant temperature. The coolant sensor is located in the block. The sensor turns the radiator cooling fan on whenever the engine temperature rises above a predetermined setting.)



FORD RELAY



G.M. RELAY



C. Blower fan controls

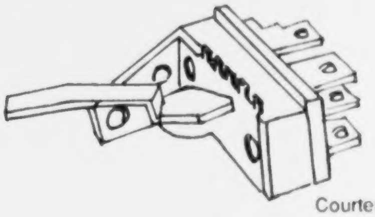
1. There are two different designs of blower fan motors: those with a single winding and those with multiple (stepped) windings. Each design requires a specific type of control circuit.

   a. A single-winding motor is used in conjunction with a voltage dividing resistor. The dash switch selects combinations of resistors to achieve the desired motor speed.

   b. Multiple-speed blower motors have stepped windings. The dash control energizes each winding to achieve multiple speeds.

2. On most blower motors, a high-speed blower relay energizes the motor to full battery voltage when the highest speed (highest current draw) position is selected on the switch.

3. The blower speed switch is a multi-position switch. This switch directs current flow to various windings on a multiple-speed (stepped-winding) blower motor. The switch also directs current to various resistors or to the high-speed relay on a single-winding motor.



Courtesy of Murray Corporation

AS1-L2-UII

MODULE: HEATING AND AIR CONDITIONING

COMPONENTS OF THE AUTOMOTIVE AIR CONDITIONING SYSTEM

Instructions: **Do the following tasks and answer the following questions. Write all responses on this sheet.**

1. Define the following terms:

Accumulator

Clutch

Clutch cycling switch

Compressor

Cycling orifice tube system

Drier

Expansion valve

Thermostatic switch

2. Listed below are several phases of an automotive air conditioning system. Describe what happens to freon in each of these phases. Describe the freon as being hot or cool or under low or high pressure during each phase.

Evaporation phase

Compression phase

Condensation phase

Drying and storage phase

Expansion phase

3. Name the major component responsible for compression of freon within an automotive air conditioning system.

4. Name the three major components responsible for the expansion of freon within an automotive air conditioning system.

5. Name the major component responsible for the evaporation of freon within an automotive air conditioning system.

6. Name the two major components responsible for moisture removal within an automotive air conditioning system.

7. Name the major component responsible for condensation of freon within an automotive air conditioning system.

8. List five compressor protection devices within an automotive air conditioning system. Also describe precisely what protection each device offers.

9. Name two devices that control evaporator flow rate within an automotive air conditioning system.

10. Name the devices that control evaporator outlet pressure and temperature within an automotive air conditioning system.

11. Name the device that removes moisture within an automotive air conditioning system. Also name the device that serves as a reservoir within an automotive air conditioning system.

12. Describe the location of the accumulator within an automotive air conditioning system.

13. Describe the function of the EPR valve within an automotive air conditioning system.

14. Name the basic parts of an expansion valve air conditioning system.

15. Name the basic parts of an orifice tube air conditioning system.

16. Describe how the compressor cycle is controlled on a fixed-orifice-tube air conditioning system.

17. Name three cycle-cutout switches and describe the function of each.

18. Describe two ways by which the engine coolant fan is controlled.

19. Name three devices that control the speed of the air conditioner's blower.

MODULE: HEATING AND AIR CONDITIONING

COMPONENTS OF THE AUTOMOTIVE AIR CONDITIONING SYSTEM

(ANSWER SHEET)

1. The accumulator is located in the low side of the automotive air conditioning system. The accumulator stores freon, separates liquid oil and liquid freon from vapor, and absorbs moisture in the air conditioning system.

   In an automotive air conditioning system, a clutch is an electromechanical device that couples the drive pulley to the compressor shaft.

   The clutch cycling switch engages or disengages the compressor clutch in relation to evaporator pressure or temperature.

   A compressor is a pump that circulates freon through the air conditioning system. The compressor also raises the pressure and temperature of freon.

   The cycling orifice tube air conditioning system uses an accumulator and an orifice tube instead of an expansion valve.

   A drier is usually a canister that contains desiccant. The drier serves multiple functions within the air conditioning system.

   The expansion valve regulates freon flow into the evaporator inlet on the basis of temperature and pressure.

   The thermostatic switch cycles the compressor clutch on the basis of evaporator temperature.

2. During the evaporation phase, freon absorbs heat within the evaporator and boils into a vapor. The freon enters the evaporator as a cool liquid and exits as a warm, low-pressure gas.

   During the compression phase, freon enters the compressor as a warm, low-pressure gas. Once in the compressor, the freon is changed into a hot, high-pressure gas.

   During the condensation phase, freon enters the condenser as a hot, high-pressure gas. While in the condenser, the freon is converted into a warm, high-pressure liquid.

   During the drying and storage phase, moisture is removed from the freon. The freon enters the receiver-drier as a cold, low-pressure liquid and exits in the same condition.

   During the expansion phase, freon pressure is reduced as a result of expansion. Freon enters the expansion valve as a hot, high-pressure gas and leaves the valve as a cool, low-pressure liquid. This cool, low-pressure liquid is then changed into a gas as it encounters heat in the evaporator.

3. Compressor

4. Expansion valve and orifice tube

5. Evaporator

6. Receiver drier and accumulator

7. Condenser

8. EPR--prevents liquid freon from entering the compressor inlet.

   Overheat switch--prevents compressor operation when the system contains no freon.

   Pressure cutout--prevents compressor operation when system pressure is too high or too low.

   Pressure relief--eliminates excess compressor outlet pressure.

   Ambient temperature--prevents compressor operation below 50° F.

9. The thermostatic expansion valve and the fixed-orifice tube

10. The pressure-activated evaporator control valve and the temperature-activated evaporator outlet control valve

11. Receiver-drier and accumulator

12. On the fixed-orifice-tube system, the accumulator is located on the outlet of the evaporator.

13. The EPR valve regulates evaporator outlet pressure.

14. Expansion valve
    Evaporator
    Compressor
    Condenser
    Receiver-drier

15. Orifice tube
    Evaporator
    Accumulator
    Compressor
    Condenser

16. On a fixed-orifice-tube system, the compressor is controlled by a cycling pressure switch.

17. Low-pressure cutout--stops compressor cycling when freon pressure becomes too low.

    High-pressure cutout--stops compressor cycling when freon pressure becomes too high.

    Time-delay relay cutout--delays compressor operation to prevent stalling of the engine.

    WOT cutout--opens compressor clutch circuit when engine throttle is wide open so that engine load is reduced.

18. The engine coolant fan is controlled by torque or temperature.

19. The speed of the air conditioner's blower is controlled by a multiple-speed motor, the stepped resistor switch, and the high-blower relay.

MODULE : HEATING AND AIR CONDITIONING

UNIT II: AUTOMOTIVE AIR CONDITIONING SYSTEM DESIGN

UNIT II TEST

SECTION A. Match the terms below with their appropriate definitions.

____ 1. Regulates freon flow into the evaporator inlet on the basis of temperature and pressure.

____ 2. An electromechanical device that couples the drive pulley to the compressor shaft.

____ 3. A receiver-drier device located in the low side of the automotive air conditioning system. This device stores freon, separates liquid oil and freon from vapor, and absorbs moisture in the air conditioning system.

____ 4. A device (usually a canister) containing desiccant.

____ 5. A pump that circulates freon through the air conditioning system.

____ 6. Line or passage that ensures a continuous supply of oil vapor to the compressor.

____ 7. A chemical agent used to absorb moisture from freon in air conditioning systems.

a. Accumulator
b. Capillary tube
c. Clutch
d. Compressor
e. Desiccant
ab. Drier
ac. Equalizer line
ad. Expansion valve
ae. Oil bleed

SECTION B. Read each of the following statements carefully. Indicate whether each statement is true or false by placing a T or F in the blank beside it.

____ 8. The evaporator consists of a series of coils mounted in groups of fins.

____ 9. By changing from liquid to vapor, the freon releases heat into the air around the evaporator.

____ 10. During the refrigeration cycle, high-pressure, high-temperature freon gas enters the compressor inlet and exits the discharge outlet as a warm, low-pressure gas.

____ 11. During the condensation phase of air conditioning operation, the heat contained in the hot freon gas is transferred to the cooler surrounding air. The freon gas then condenses into a warm liquid.

____ 12. The receiver-drier accumulator in an air conditioning system can be located after the condenser or before the compressor, depending upon the system design.

____ 13. Water in an air conditioning system will lower the boiling point of freon and cause the system to work less efficiently.

____ 14. The high side of the air conditioning system lies between the expansion valve and the suction side of the compressor.

____ 15. The low side of the air conditioning system lies between the discharge of the compressor and the expansion valve or orifice tube.

____ 16. Head pressure works against compressor discharge pressure in the air conditioning system.

____ 17. In automotive systems, a capillary tube measures the temperature of the evaporator coil. Based upon that measurement, the tube activates or deactivates the compressor's magnetic clutch.

____ 18. Since the early 1980's, fixed-orifice tubes have replaced expansion valves in many automotive air conditioning systems.

____ 19. An ambient temperature cutout stops compressor activity when temperatures inside the air conditioning system fall below -20°F.

____ 20. Components in the suction throttling valve system (pressure type) are the same as those in the thermostatic system except for the addition of an STV valve.

____ 21. The evaporator pressure regulator system (pressure type) uses an STV valve.

____ 22. In the five-part, fixed-orifice, cycling-clutch system, cycling is controlled in part by a thermostatic switch located in the outlet side of the evaporator.

____ 22. The temperature-control switch on the dashboard controls the thermostatic switch in the fixed-orifice, cycling-clutch, thermostatic-control system.

____ 23. The constant-run system (a constantly engaged compressor system) uses a cycling pressure switch.

____ 24. A time-delay relay switch keeps the air conditioning clutch circuit open for a period of 10 to 30 seconds after initial engine start-up to allow the engine idle to stabilize.

____ 25. A power-brake, time-delay relay switch interrupts the clutch circuit for 3 to 5 seconds after the brakes are applied.

____ 26. WOT stands for wide-open-throttle switch.

____ 27. Torque-operated (viscous) fans maintain the same rpm as the engine.

____ 28. Temperature-controlled fans may run after the engine is shut off.

____ 29. The dash control energizes every other winding of a multiple-speed blower motor in order to achieve multiple speeds.

SECTION C. Select the best answer from the five choices listed.

____ 30. In the air conditioning system, the expansion valve makes use of

a. a filter screen.
b. a meter orifice.
c. a pressure or temperature control.
d. all of the above.
e. none of the above.

___ 31. In the air conditioning system, the expansion valve works to

a. reduce the pressure of the freon through expansion.
b. regulate the flow rate of freon based upon evaporator temperature or pressure.
c. filter any debris or ice that may be in the freon.
d. do all of the above.
e. do none of the above.

___ 32. During the refrigeration cycle of the air conditioning system, freon (in the form of a high-pressure liquid) passes through the expansion valve and then flows into the evaporator where it

a. disperses heat into the surrounding air.
b. achieves a higher pressure.
c. achieves a higher boiling point.
d. does all of the above.
e. does none of the above.

___ 33. The type of compressor in which the pistons move at a 90-degree angle to the crankshaft center line is

a. the V or in-line reciprocating piston compressor.
b. the axial-flow compressor.
c. the radial-cylinder compressor.
d. the vane-pump compressor.
e. none of the above.

___ 34. The type of compressor that has no pistons is

a. the V or in-line reciprocating piston compressor.
b. the axial-flow compressor.
c. the radial-cylinder compressor.
d. the vane-pump compressor.
e. none of the above.

___ 35. The type of compressor in which the cylinders radiate from the center line of the compressor shaft is

a. the V or in-line reciprocating piston compressor.
b. the axial-flow compressor.
c. the radial-cylinder compressor.
d. the vane-pump compressor.
e. none of the above.

___ 36. The type of compressor in which the reciprocating motion of the axle swatch plate moves the pistons is

a. the V or in-line reciprocating piston compressor.
b. the axial-flow compressor.
c. the radial-cylinder compressor.
d. the vane-pump compressor.
e. none of the above.

___ 37. When freon is too low to sustain cooling in the air conditioning system, an overheat switch in the compressor eliminates clutch activity by

a. blocking freon flow to the compressor.
b. blocking freon flow to the condenser.
c. blocking freon flow to the evaporator.
d. venting freon into the atmosphere.
e. blowing a thermal fuse.

___ 38. The accumulator is located

a. at the outlet of the evaporator.
b. at the inlet of the evaporator.
c. at the outlet of the condenser.
d. at the inlet of the condenser.
e. in none of the above locations.

___ 39. In reference to receiver-driers, VIR means

a. vacuum-interlocked receiver.
b. vapor-interlocked receiver.
c. vapor-inducing receiver.
d. volume-interfacing receiver.
e. none of the above.

___ 40. The orifice tube meters the freon flow according to the amount of pressure exerted against the orifice by the compressor and

a. the fixed length of the orifice tube.
b. the fixed size of the orifice opening.
c. the fixed circumference of the orifice tube.
d. the fixed length and circumference of the orifice tube combined with the fixed size of the orifice opening.
e. none of the above.

(NOTE: The student must obtain a minimum score of ___ on the Unit II Test in order to receive an evaluation for Competencies Gg1-Gg4.)

ANSWERS TO UNIT II TEST

1.	ad
2.	c
3.	a
4.	ab
5.	d
6.	ac
7.	e
8.	t
9.	f
10.	f
11.	t
12.	t
13.	f
14.	f
15.	f
16.	f
17.	t
18.	t
19.	f
20.	t
21.	f
22.	f
23.	f
24.	t
25.	t
26.	t
27.	f
28.	f
29.	d
30.	d
31.	e
32.	b
33.	a
34.	d
35.	b
36.	e
37.	d
38.	a
39.	e
40.	a

MODULE: HEATING AND AIR CONDITIONING

UNIT III: AUTOMOTIVE AIR CONDITIONING SYSTEM SERVICE

UNIT OBJECTIVE

After completing this unit, the student should be able to perform basic service and diagnostic procedures on an automotive air conditioning system. The student will demonstrate mastery of the material by achieving a score of _____ on the unit test.

SPECIFIC OBJECTIVES

After completing the lesson in this unit, the student should be able to:

Lesson 1. I. Identify terms and definitions associated with automotive air conditioning service (Competency Gg1, Unit III Test).

II. Identify appropriate safety procedures for diagnosing and servicing an automotive air conditioning system (Competency Gg1, Unit III Test).

III. Identify equipment used in servicing an automotive air conditioning system (Competency Gg1, Unit III Test).

ASE TASKS COVERED IN THIS UNIT

I. Only material that is preliminary to ASE tasks appears in this unit; therefore, no ASE tasks are covered directly.

MODULE: HEATING AND AIR CONDITIONING

UNIT III: AUTOMOTIVE AIR CONDITIONING SYSTEM SERVICE

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

  1. Lesson 1: SERVICE EQUIPMENT FOR THE AUTOMOTIVE AIR CONDITIONING SYSTEM

    a. Information outline

    b. Assignment sheet

    AS1-L1-UIII: Service Equipment for the Air Conditioning System

E. Unit test

F. Answers to unit test

REFERENCES

Carter Carburetor Division, ACF Industries, Inc. Automotive Air Conditioning Theory and Practice.

Mitchell Information Services, Inc. Heating and Air Conditioning Systems. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1987.

Mitchell International, Inc. Automotive Air Conditioning Basic Service Training Manual. 21st ed. San Diego, CA: Mitchell International Inc., 1988.

Mitchell Manuals, Inc. 1984 Edition Automotive Air Conditioning Basic Service Training Manual. San Diego, CA: Mitchell Manuals, Inc., 1984.

Murray Corporation. Dealer Education Program Temperature Control Clinic Workbook. Cockeysville, MD: Murray Corporation, 1988.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

  1. Students should do AS1-L1-UIII before taking the Unit III Test.

B. Suggested audio-visual material from The Media Center, State Fair Community College, Sedalia, Mo.

  1. Air Conditioner Charging (AM-83-310), 1983.

  2. Air Conditioning Manifold Gauge Set: Hook-Up and Diagnostic Use (AM-86-311), 1986.

MODULE: HEATING AND AIR CONDITIONING

UNIT III: AUTOMOTIVE AIR CONDITIONING SYSTEM SERVICE

LESSON 1: SERVICE EQUIPMENT FOR THE AUTOMOTIVE AIR CONDITIONING SYSTEM

I. Terms and definitions

A. Auxiliary gauge--A device that measures evaporator outlet pressure in some STV-, DOA-, and EPR-controlled air conditioning systems.

B. Back seat (back seated)--A term used in reference to the position of compressor service valves. Service valves are back seated when they are turned counter clockwise as far as possible. When the valves are back seated, the service port is closed. Back seat is the normal operating position for service valves.

C. Bulk charging--A procedure in which a five- to twenty-pound freon container is used to charge an air conditioning system. Bulk charging requires that the freon container be weighed to determine the amount of freon charged.

D. Charge--An amount of freon measured by weight.

E. Charging station--A monolithic unit used for evacuating, testing, and charging air conditioning systems. A charging station may use automatic controls.

F. Charging hose--A small, high-pressure hose connecting freon containers to the manifold gauge set.

G. Compound gauge--A pressure and vacuum gauge used on the low side of the manifold gauge set.

H. Discharge--A procedure in which pressurized freon is allowed to escape through a valve or opening in the air conditioning system.

I. Discharge pressure--Compressor outlet pressure.

J. Evacuate--A procedure in which all air, freon, and moisture is eliminated from an air conditioning system. A vacuum pump is usually used to evacuate an air conditioning system.

K. Flush--A procedure in which the air conditioning system is purged of solid contaminants. Air conditioning systems are usually flushed with either freon or a special solvent.

L. Foaming--The appearance of foam in an air conditioning system. Foaming occurs when freon boils away from the refrigerant oil as a result of a rapid drop in system pressure. The presence of foam in the sight glass indicates that the system has a low freon charge.

M. Freeze-up--The formation of ice at the expansion valve/orifice tube or the collection of ice on the evaporator fins. Ice on the evaporator fins blocks air flow.

N. Front seat (front seated)--A term used in reference to the position of compressor service valves. Service valves are front seated when they are turned clockwise as far as possible. When placed in the front-seat position, service valves isolate the compressor from the rest of the air conditioning system. Valves are front seated to allow for service of the system.

O. Head pressure--Same as discharge pressure.

P. High side--The section of the air conditioning system that runs from the compressor outlet to the expansion valve or orifice tube.

Q. Leak detector--A gas or electronic device that indicates a freon leak in the air conditioning system.

R. Low head pressure--A lower-than-acceptable compressor discharge pressure in an air conditioning system.

S. Low side--The section of the air conditioning system that runs from the evaporator to the compressor inlet.

T. Low suction pressure--A lower-than-acceptable low-side pressure in an air conditioning system.

U. Manifold gauge set--A device for servicing air conditioning systems. The manifold gauge set has gauges and connecting hoses for system diagnosis.

V. Overcharge--Excessive refrigerant or oil charge in the air conditioning system.

W. Performance test--A test that measures optimum system operation against acceptable system pressures and temperatures.

X. Schrader valve--A service port (valve) that is self-sealing.

Y. Service port--Points through which the inside of the air conditioning system can be accessed for the purpose of testing, discharging and charging. The manifold gauge set can be attached to a service port.

Z. Sight glass--A service window through which freon flow can be observed. The sight glass is useful in measuring system performance.

AA. Suction pressure--Compressor inlet pressure.

AB. Undercharge--An insufficient freon charge in the air conditioning system.

AC. Vacuum pump--A pump that evacuates air, freon, and moisture from the air conditioning system.

II. Safety in servicing air conditioning systems

A. Handling freon improperly can result in frozen skin, asphyxiation, and exposure to poisonous gas.

1. If freon touches the skin, frost bite and severe blisters may result. Freon can also cause permanent blindness if it contacts the eyes. When working with freon, wear clothing that covers as much exposed skin as possible. Also wear eye protection.

2. Freon is heavy enough to displace air. A person could be asphyxiated if he or she were in a closed area where freon had collected. Proper ventilation should always be used to remove freon from the work area.

3. If left undisturbed, freon is a colorless, odorless, nontoxic gas. When freon is exposed to flame, however, it turns into phosgene, a very poisonous gas. In the shop, freon can contact flames in hot water heaters, furnaces, or running engines. Proper ventilation is required to avoid excessive build-up of freon around sources of flame.

4. Freon expands rapidly when exposed to high heat. Freon is often sold in 14-oz containers made of thin metal. If exposed to high temperatures, a charging container could develop enough internal pressure to explode, throwing shreds of metal into the surrounding area.

5. Air conditioning systems routinely operate at very high pressure. Care must be taken to ensure that freon pressure within the system does not become high enough to cause an explosion.

   (**CAUTION:** If freon containers come under too much pressure, they can explode. The air conditioning system itself may explode if the freon pressure inside becomes excessive.)

   (**CAUTION:** Never store freon in a location where the temperature exceeds 125°F.)

   (**CAUTION:** To prevent injury, make sure gauge sets are working properly. Also make sure gauge sets are connected properly.)

III. Air conditioning system service equipment

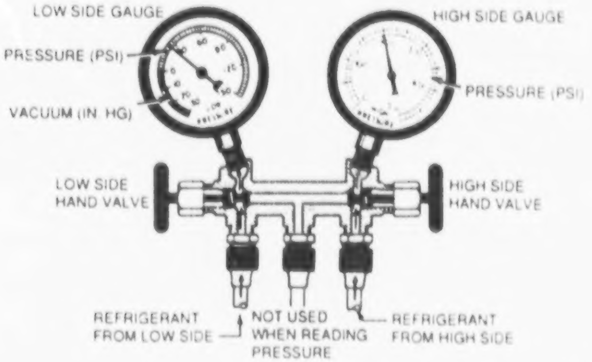
A. Manifold gauge set

1. Construction of the manifold gauge set

   a. The manifold portion of the gauge set is constructed of brass and contains two isolation valves along with a high-pressure gauge and a low-pressure gauge. Internal passages in the manifold connect the gauges to the service hoses.

   b. Isolation valves connect the manifold's center service port to either side of the manifold.

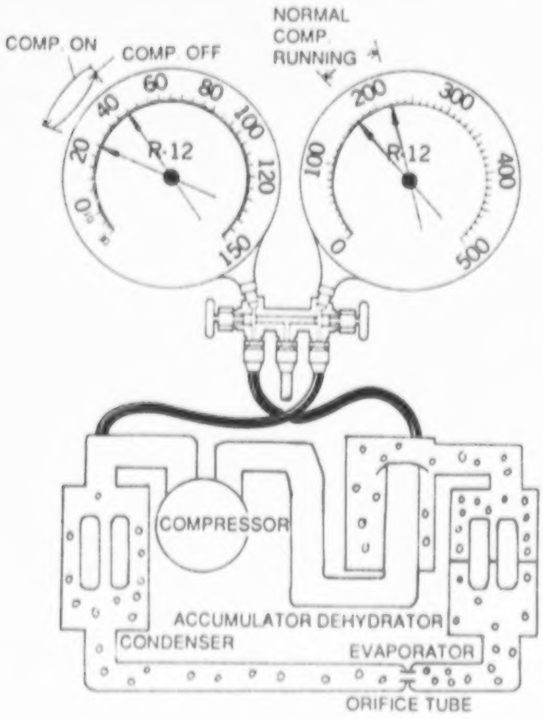
   c. The manifold gauge set uses a low-pressure service hose, a high-pressure service hose, and a charging and evacuation hose. The hose ends have a special service connection containing an internal valve depressor. This special service connection opens the Schrader valve when the service hose is screwed onto the service port.


LOW SIDE GAUGE
HIGH SIDE GAUGE
PRESSURE (PSI)
PRESSURE (PSI)
VACUUM (IN. HG)
LOW SIDE HAND VALVE
HIGH SIDE HAND VALVE
REFRIGERANT FROM LOW SIDE
NOT USED WHEN READING PRESSURE
REFRIGERANT FROM HIGH SIDE

Courtesy of Mitchell Information Services, Inc

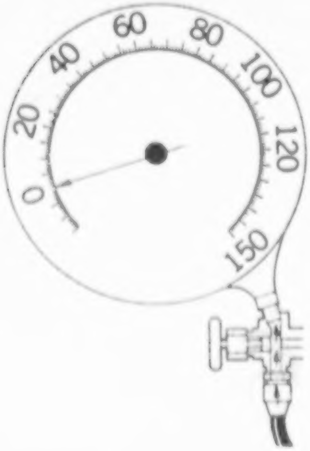
2. Function of the gauge set

a. When connected to the low-side service port, the gauge set's low-pressure hose (which is usually blue) indicates the amount of pressure in the low side of the air conditioning system.


COMP. ON
COMP. OFF
NORMAL COMP. RUNNING
R-12
0
20
40
60
80
100
120
150
R-12
0
100
200
300
400
500
COMPRESSOR
ACCUMULATOR DEHYDRATOR
CONDENSER
EVAPORATOR
ORIFICE TUBE

b. When connected to the high-side service port, the gauge set's high-pressure hose (which is usually red) indicates the amount of pressure in the high-side of the air conditioning system.

c. When closed, the low-side isolation valve cuts off the low-pressure hose from the center service hose. When opened (during system charging), the valve allows freon to enter through the center hose. Freon then moves through the low-pressure hose, past the service port and into the system. When open (during system discharge), the low-side isolation valve will allow freon to move from the system's low side through the low-pressure hose and then to the center hose. The freon then moves to the evacuation unit.



d. When closed, the high-side isolation valve isolates the high-side service hose from the center service hose. The high-side isolation valve is opened only during evacuation and final discharging of the air conditioning system.

(**CAUTION:** Never open the high-side valve unless the air conditioning system is being discharged or evacuated. Never open the high-side valve while the system is running.)

(**CAUTION:** If the high-side valve is opened at the wrong time, the compressor could be destroyed or the charge containers could explode.)

3. Air conditioning systems with evaporator outlet controls have a third service port for an auxiliary gauge. The auxiliary gauge provides the outlet pressure reading.

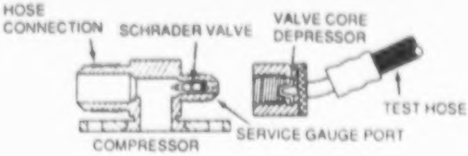
AUX. LOW SIDE
NORMAL

Courtesy of Mitchell Information Services, Inc.

B. System service ports and valves

1. The Schrader valve is a spring-loaded service valve. The valve opens when its pin and core assembly is depressed, thus allowing freon to pass in or out of the system. When the Schrader valve is released, it automatically reseats, thus stopping freon flow. As the service gauge hose fitting is being tightened, a special connector on the service gauge hose will depress the valve's pin and core assembly.

   (**CAUTION:** Some freon usually escapes as the service hose is being connected to or disconnected from the Schrader valve. The technician should protect his or her fingers when connecting or disconnecting the hose.)



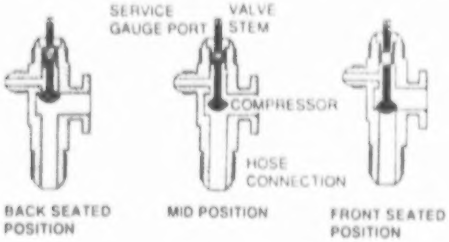
Courtesy of Mitchell Information Services, Inc

2. The stem (mechanical) service valve is opened and closed manually. The valve has three positions of operation: back seat, mid position, and front seat.

   a. When the stem service valve is back seated, the service port is isolated from the rest of the air conditioning system.

   b. When the stem service valve is in mid position (mid way between the front seat and back seat positions), the air conditioning system can be performance tested, charged, and evacuated. The stem service valve should not be left in mid position after servicing.

   c. When the stem service valve is front seated, the compressor is isolated from the rest of the air conditioning system. When the compressor is isolated, it can be serviced without discharging the system.



Courtesy of Mitchell Information Services, Inc.

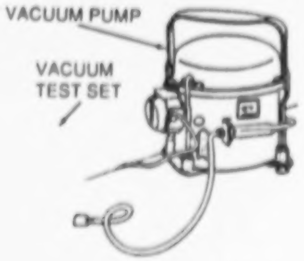
C. Monitoring devices

1. A dial or mercury bulb thermometer measures the temperature of evaporator outlet air. The thermometer is useful in comparing the relationship between the pressure in the line and the temperature at the vent nearest the evaporator.

2. A sound detector is a noise-sensitive electronic instrument. The sound detector senses the presence of foam or bubbles in the air conditioning system's freon stream. Foam or bubbles indicate a low freon charge within the system. A sound detector is useful when no sight glass is available.

D. Evacuating device

1. The vacuum pump is an electrically powered device that evacuates air from the air conditioning system. The vacuum created by the pump can also be used to determine if the system is capable of holding a charge of freon. A manifold gauge set must be used to determine if a vacuum is present within the system.

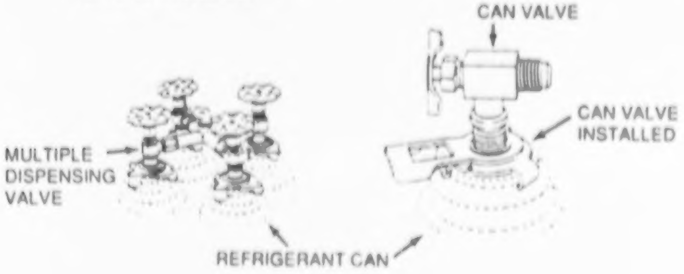

VACUUM PUMP
VACUUM TEST SET

Courtesy of Chrysler Motors Corporation

E. Charging equipment

1. When charging an air conditioning system, the technician must use a dispensing valve (either the flat-seal or screw-seal type) to transfer the freon from the container to the system. The technician can also use a complete charging system, which has all the components necessary for charging and evacuation.

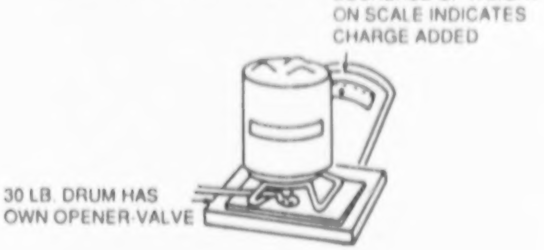
   a. The flat-seal dispensing valve is used with single or multiple 14-oz cans of freon. The flat-seal valve is self-piercing and will open the can's seal as the valve is installed.


CAN VALVE
MULTIPLE DISPENSING VALVE
CAN VALVE INSTALLED
REFRIGERANT CAN

Courtesy of Mitchell Information Services, Inc

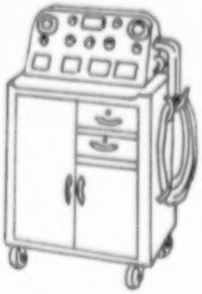
   b. The screw-seal dispensing valve has a simple service tap with a screw valve on the freon drum. This valve is used primarily with bulk freon containers.

   (NOTE: Before and after charging a system with the screw-seal dispensing valve, the technician must use a separate device to measure the weight of the freon container.)


DECREASE OF WEIGHT ON SCALE INDICATES CHARGE ADDED
30 LB. DRUM HAS OWN OPENER-VALVE

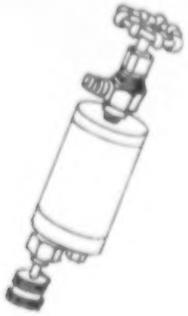
Courtesy of General Motors Corporation

c. A charging system contains gauges, a pump, and a bulk dispenser--all the components needed for charging and evacuation. The charging system also contains a freon recovery system.



2. An oil-injection device dispenses pre-measured amounts of refrigerant oil into the system.

   a. The refrigerant oil dispenser is connected in the line between the freon charging device and the low side of the system. The oil is added as the system is recharged.



   b. A 14-oz can of oil can be connected to a flat-seal dispensing valve. The oil in the can is under pressure and, therefore, forced into the low side of the system.

F. Some air conditioning systems have a built-in sight glass. The sight glass allows for a visual inspection of freon flow.

(NOTE: Evaluation of the air conditioning system's performance should not be based on sight glass observations alone. Gauge set readings should be considered along with sight glass observations.)

MODULE: HEATING AND AIR CONDITIONING

SERVICE EQUIPMENT FOR THE AUTOMOTIVE AIR CONDITIONING SYSTEM

Instructions: **Do the following tasks and answer the following questions. Write all responses on this sheet.**

1. Define the terms listed below.

   Discharge

   Evacuate

   High side

   Low side

   Manifold gauge set

   Performance test

   Sight glass

   Undercharge

2. List four dangers associated with freon.

3. What are service ports in an air conditioning system?

4. What device is used to evacuate the air conditioning system?

MODULE: HEATING AND AIR CONDITIONING

SERVICE EQUIPMENT FOR THE AUTOMOTIVE AIR CONDITIONING SYSTEM

(ANSWER SHEET)

1. Discharging is a procedure in which pressurized freon is allowed to escape through a valve or opening in the air conditioning system.

   Evacuation is a procedure in which all air, freon, and moisture is eliminated from an air conditioning system. A vacuum pump is usually used to evacuate an air conditioning system.

   High side is the section of the air conditioning system that runs from the compressor outlet to the expansion valve or orifice tube.

   Low side is the section of the air conditioning system that runs from the evaporator to the compressor inlet.

   A manifold gauge set is a device for servicing air conditioning systems. The manifold gauge set has gauges and connecting hoses for system diagnosis.

   A performance test measures optimum system operation against acceptable system pressures and temperatures.

   A sight glass is a service window through which freon flow can be observed. The sight glass is useful in measuring system performance.

   Undercharge is an insufficient freon charge in the air conditioning system.

2. If freon touches the skin, frost bite and severe blisters may result. Freon can also cause permanent blindness if it contacts the eyes.

   Freon is heavy enough to displace air. A person could be asphyxiated if he or she were in a closed area where freon had collected.

   When freon is exposed to flame, however, it turns into phosgene, a very poisonous gas.

   If exposed to high temperatures, a freon charging container could develop enough internal pressure to explode, throwing shreds of metal into the surrounding area.

3. Service ports are points in the air conditioning system at which gauges are connected.

4. Vacuum pump

MODULE: HEATING AND AIR CONDITIONING

UNIT III: AUTOMOTIVE AIR CONDITIONING SYSTEM SERVICE

UNIT III TEST

SECTION A. Match the terms below with their appropriate definitions.

____ 1. Term applied to air conditioning service valves that are turned clockwise as far as possible.

____ 2. Procedure in which pressurized freon is allowed to escape through a valve or opening in the air conditioning system.

____ 3. Procedure in which all air, freon, or moisture is eliminated from an air conditioning system.

____ 4. Procedure in which the air conditioning system is purged of solid contaminants.

____ 5. Term applied to air conditioning service valves when they are turned counter clockwise as far as possible.

____ 6. A device consisting of gauges and connecting hoses which can be used to diagnose an air conditioning system.

____ 7. A pressure and vacuum gauge used on the low side of the manifold gauge set.

____ 8. A special, self-sealing service port.

a. Back seat
b. Compound gauge
c. Discharge
d. Evacuate
e. Flush
ab. Front seat
ac. Manifold gauge set
ad. Schrader valve
ae. Undercharge

SECTION B. Select the best answer from the five choices listed.

____ 9. Handling freon improperly can result in

a. frozen skin.
b. asphyxiation.
c. exposure to poisonous gas.
d. an explosion of the freon container.
e. all of the above.

____ 10. The manifold portion of the manifold gauge set is constructed of

a. brass.
b. rubber.
c. aluminum.
d. stainless steel.
e. none of the above.

____ 11. The manifold gauge set uses

a. a low-pressure service hose.
b. a high-pressure service hose.
c. a charging and evacuation hose.
d. all of the above.
e. none of the above.

____ 12. When the low-side isolation valve is closed

a. the low-pressure hose is connected to the center service hose.
b. the low-pressure hose is isolated from the center service hose.
c. a vacuum is created in both the low-pressure hose and the center service hose.
d. the pressure is equalized in both the low-pressure hose and the center service hose.
e. none of the above occurs.

____ 13. The high-side isolation valve on the manifold gauge set is opened

a. only during full charging of the air conditioning system.
b. only during partial charging of the air conditioning system.
c. only during evacuation and final discharging of the air conditioning system.
d. only during a test of pressure within the air conditioning system.
e. in none of the above situations.

____ 14. When the stem service valve on an air conditioning system is back seated,

a. the system can be performance tested, charged, and evacuated.
b. refrigerant oil can be added to the system.
c. the compressor is isolated from the rest of the system.
d. all of the above are true.
e. none of the above are true.

____ 15. A vacuum pump is an electrically powered device that

a. evacuates air from the air conditioning system.
b. forces freon into the air conditioning system from bulk containers.
c. maintains freon flow within the air conditioning system.
d. helps to create air flow around the evaporator.
e. does none of the above.

SECTION C. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 16. The flat seal dispensing valve is used with single or multiple 14-oz cans of freon.

____ 17. The screw seal dispensing valve is used primarily with bulk freon containers.

____ 18. A charging system is primarily used with 14-oz freon containers.

____ 19. In many air conditioning systems, sight glasses contain a built-in gauge, which determines internal system pressure.

____ 20. A charge of freon is measured by weight.

____ 21. A charging station can be used for evacuating, testing, and charging an air conditioning system.

____ 22. The high side of the air conditioning system runs from the compressor outlet to the expansion valve.

____ 23. The Schrader valve is closed when its pin and core assembly is depressed.

____ 24. Stem service valves open and close automatically.

____ 25. The manifold gauge set will read 1 when a nonaccumulator air conditioning system is completely discharged.

(NOTE: The student must obtain a minimum score of _____ on the Unit III Test in order to receive an evaluation for Competency Gg1.)

ANSWERS TO UNIT III TEST

1.	ab
2.	c
3.	d
4.	e
5.	a
6.	ac
7.	b
8.	ab
9.	e
10.	a
11.	d
12.	b
13.	c
14.	e
15.	a
16.	t
17.	t
18.	f
19.	f
20.	t
21.	t
22.	t
23.	f
24.	f
25.	f

MODULE: HEATING AND AIR CONDITIONING

UNIT IV: SERVICING THE AUTOMOTIVE AIR CONDITIONING SYSTEM

UNIT OBJECTIVE

After completing this unit, the student should be able to perform basic service and diagnostic procedures on an automotive air conditioning system. The student will demonstrate mastery of the material by achieving a score of _____ on the unit test and by successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lesson in this unit, the student should be able to:

Lesson 1.

I. Identify procedures for inspecting the external operation of the automotive air conditioning system and determining the system's state-of-charge (Competency Gg1, Part II of the Unit IV Test).

II. Identify procedures for diagnosing the automotive air conditioning system (Competency Gg1, Part II of the Unit IV Test).

III. Identify procedures for servicing the air conditioning system (Competency Gg3, Part I of the Unit IV Test).

IV. Demonstrate the ability to:

- a. Make preliminary inspections of an automotive air conditioning system (Competency Gg1, JS1-L1-UIV).
- b. Performance test the automotive air conditioning system (Competency Gg1, JS2-L1-UIV).
- c. Diagnose the performance of the automotive air conditioning system (Competency Gg1, JS3-L1-UIV).
- d. Discharge a nonaccumulator air conditioning system (Competency Gg3, JS4-L1-UIV).
- e. Discharge an accumulator air conditioning system (Competency Gg3, JS5-L1-UIV).
- f. Check compressor oil (Competency Gg2, JS6-L1-UIV).
- g. Evacuate and charge an automotive air conditioning system (Competency Gg3, JS7-L1-UIV).
- h. Partially charge an automotive air conditioning system (Competency Gg3, JS8-L1-UIV).
- i. Test an automotive air conditioning system for leaks (Competency Gg1, JS9-L1-UIV).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks G002-G006, G009-G012, G017, G038, and G042-G044.

MODULE: HEATING AND AIR CONDITIONING

UNIT IV: SERVICING THE AUTOMOTIVE AIR CONDITIONING SYSTEM

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: PROCEDURES FOR DIAGNOSING AND SERVICING THE AUTOMOTIVE AIR CONDITIONING SYSTEM

    a. Information outline

    b. Assignment sheets

        AS1-L1-UIV: Servicing Components of the Automotive Air Conditioning System
        AS2-L1-UIV: Procedure for Checking Compressor Oil

    c. Job sheets

        JS1-L1-UIV: Making Preliminary Inspections of an Automotive Air Conditioning System
        JS2-L1-UIV: Performance Testing the Automotive Air Conditioning System
        JS3-L1-UIV: Diagnosing the Performance of the Automotive Air Conditioning System
        JS4-L1-UIV: Discharging a Nonaccumulator Air Conditioning System
        JS5-L1-UIV: Discharging an Accumulator Air Conditioning System
        JS6-L1-UIV: Checking Compressor Oil
        JS7-L1-UIV: Evacuating and Charging an Automotive Air Conditioning System
        JS8-L1-UIV: Partially Charging an Automotive Air Conditioning System
        JS9-L1-UIV: Testing an Automotive Air Conditioning System for Leaks

E. Unit test

F. Answers to unit test

REFERENCES

Carter Carburetor Division, ACF Industries, Inc. Automotive Air Conditioning Theory and Practice.

Mitchell Information Services, Inc. Heating and Air Conditioning Systems. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1987.

Mitchell International, Inc. Automotive Air Conditioning Basic Service Training Manual. 21st ed. San Diego, CA: Mitchell International Inc., 1988.

Mitchell Manuals, Inc. 1984 Edition Automotive Air Conditioning Basic Service Training Manual. San Diego, CA: Mitchell Manuals, Inc., 1984.

Murray Corporation. Dealer Education Program Temperature Control Clinic Workbook. Cockeysville, MD: Murray Corporation, 1988.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Students should do JS6-L1-UIV in conjunction with AS2-L1-UIV.
2. If the student is working with an air conditioning system that needs only a partial charge, have the student skip JS7-L1-UIV. The student can proceed to JS8-L1-UIV, which deals with partially charging an air conditioning system.
3. Item 2 of JS9-L1-UIV requires a propane leak detector. Item 3 requires an electronic leak detector. Depending on the equipment available, the student may omit either item 2 or 3.

MODULE: HEATING AND AIR CONDITIONING

UNIT IV: SERVICING THE AUTOMOTIVE AIR CONDITIONING SYSTEM

LESSON 1: PROCEDURES FOR DIAGNOSING AND SERVICING THE AUTOMOTIVE AIR CONDITIONING SYSTEM

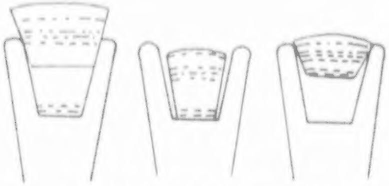
I. Procedures for inspecting the external operation of the air conditioning system and determining system state-of-charge

A. Procedure for inspecting the engine cooling system

(NOTE: The engine's cooling system should always be checked before inspecting the air conditioning system.)

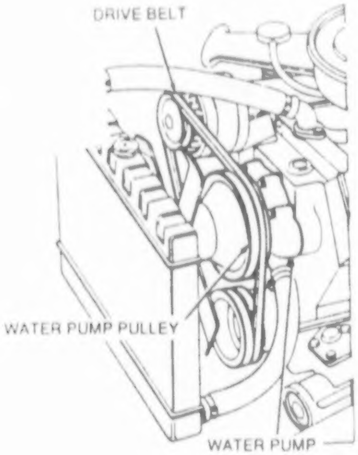
1. Inspect the condition of cooling system drive belts. Make sure belts have adequate tension and are routed correctly.

2. Make sure belt size matches pulley size. A mismatch of sizes will cause belt slippage.



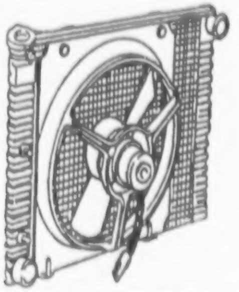
INCORRECT BELT TO PULLEY MATCH

3. Inspect and test the operation of the cooling fan clutch. Also inspect the cooling fan shroud.



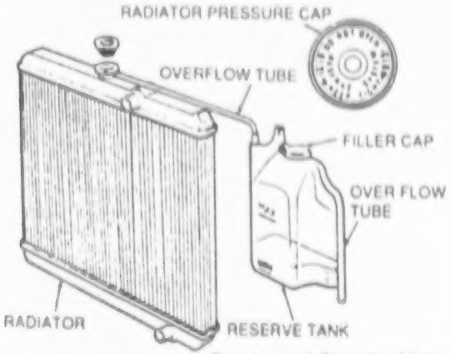
Courtesy of Chrysler Motors Corporation

4. Inspect for current engagement temperature and air conditioning relay operation. The engine cooling fan should run whenever the air conditioning switch is on.



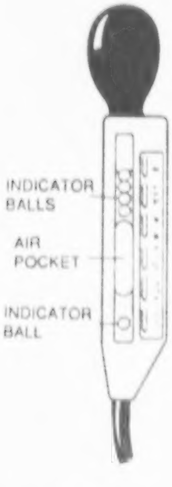
Courtesy of Chrysler Motors Corporation

5. Make sure that engine coolant level is adequate.


RADIATOR PRESSURE CAP
OVERFLOW TUBE
FILLER CAP
OVER FLOW TUBE
RADIATOR
RESERVE TANK

Courtesy of Chrysler Motors Corporation

6. Make sure that coolant freeze point is sufficiently low.


INDICATOR BALLS
AIR POCKET
INDICATOR BALL

7. Check for proper heater control valve operation where applicable.

B. Procedure for inspecting air flow around the air conditioning system

1. Inspect condenser fins for clogging and bending. Use a fan comb to straighten any flattened fins. Flush any excessive debris from the fins with a stream of water.

2. With the engine running, operate the air conditioning controls and listen for blend-air door operation. The doors should open and close when dash controls are adjusted.

C. Procedure for making an under-hood inspection of air conditioning components

1. Make sure vacuum hoses are routed and connected properly.

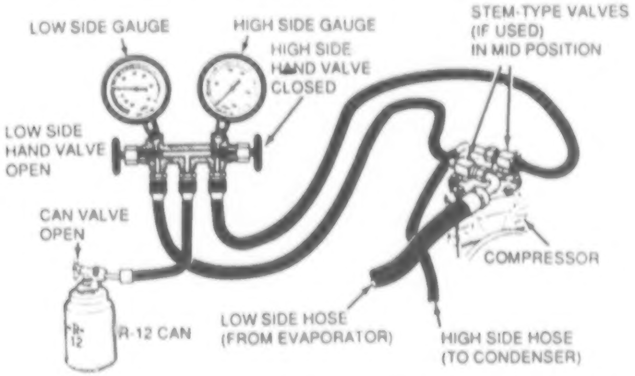
2. Make sure the air conditioning system operates properly when engine is idling.

3. Make sure air conditioning hoses do not exhibit excessive wear or damage.

4. Make sure the hoses are properly routed.

5. Make sure there is no refrigerant oil in the areas around the compressor clutch or hose connections. Refrigerant oil in these areas indicates a freon leak.

D. Procedure for testing an air conditioning system's state of charge


LOW SIDE GAUGE
HIGH SIDE GAUGE
HIGH SIDE HAND VALVE CLOSED
STEM-TYPE VALVES (IF USED) IN MID POSITION
LOW SIDE HAND VALVE OPEN
CAN VALVE OPEN
COMPRESSOR
R-12
R-12 CAN
LOW SIDE HOSE (FROM EVAPORATOR)
HIGH SIDE HOSE (TO CONDENSER)

Courtesy of Mitchell Information Services, Inc

1. Remove protective covers from the service ports or valve stem.

2. Connect the high-side gauge to the high-side service port.

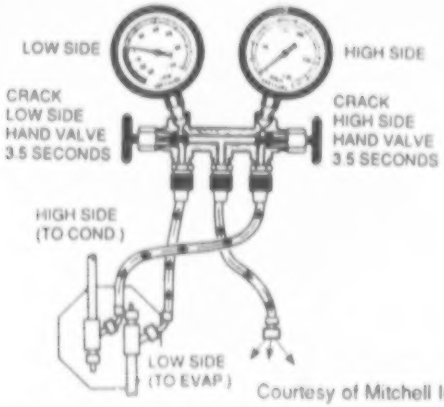
   (CAUTION: Connect gauge set only after engine has been shut off and air conditioning system has been stabilized for at least five minutes.)

   (CAUTION: When connecting gauges, make sure that the manifold valves are closed. Screw connections on quickly to reduce the risk of freon leakage. Always wear safety glasses when working with freon.)

3. Connect the low-side hose to the low-side service port.

   (CAUTION: Connect gauge set only after engine has been shut off and air conditioning system has been stabilized for at least five minutes.)

4. Purge the gauge set by placing a rag over the center discharge hose and alternately cracking the low and high manifold valves for about three seconds or until freon discharges from the center service hose. Be sure that both valves are closed before proceeding.

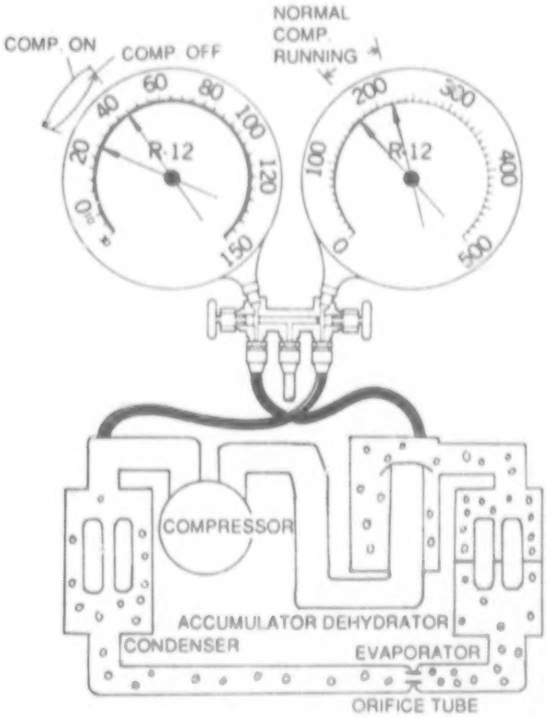

LOW SIDE
HIGH SIDE
CRACK
LOW SIDE
HAND VALVE
3.5 SECONDS
CRACK
HIGH SIDE
HAND VALVE
3.5 SECONDS
HIGH SIDE
(TO COND.)
LOW SIDE
(TO EVAP.)

Courtesy of Mitchell Information Services, Inc.

(NOTE: If the air conditioning system uses stem valves, rotate the stem halfway between full-out and full-in. Purge gauge set.)

5. Use gauge readings to check for static freon charge within the air conditioning system. The pounds per square inch (psi) of a minimum static charge would equal the system's ambient temperature. For example, an air conditioning system at 70°F would produce about a charge pressure of 70 pounds. If pressure is less than acceptable when compared to system temperature, the system may be low on charge.

(NOTE: Refer to the chart on page 9 of Unit I of this module for the minimum acceptable pressure based on ambient temperature.)


COMP. ON
COMP. OFF
NORMAL
COMP.
RUNNING
0
20
40
60
80
100
120
150
R-12
0
100
200
300
400
500
R-12
COMPRESSOR
ACCUMULATOR DEHYDRATOR
CONDENSER
EVAPORATOR
ORIFICE TUBE

6. Stabilize the system using the procedure below

   a. Arrange test hoses so that they will not contact engine parts that are hot or in motion.

   b. Start the engine and adjust its rpm to a high idle speed.

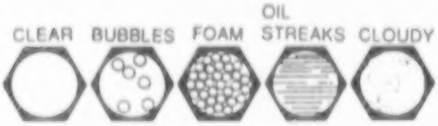
   c. Place an auxiliary fan in front of the condenser so that the auxiliary fan blows air across the condenser and radiator.

   d. Set air conditioning for maximum cool and highest blower speed. Open vehicle doors and windows and operate air conditioner at these settings for ten minutes.

   e. Determine the ambient temperature of the air conditioning system by holding a thermometer in the air blowing across the condenser. Record the ambient temperature.

   f. Determine evaporator temperature by placing the thermometer in the air conditioning duct located closest to the evaporator (usually the middle duct).

   g. Make observations through the air conditioning system's sight glass (if available).



SIGHT GLASS INDICATORS

Courtesy of Mitchell Information Services, Inc

II. Diagnosing the air conditioning system

A. Diagnosis of the refrigeration cycle of an air conditioning system centers upon the relationship between the system's ambient temperature, the system's pressure, and the system's state-of-charge. The system's temperature, pressure, and state-of-charge are closely related; a change in one will affect the others. Such changes can reduce the efficiency of heat exchange within the system.

B. Applying the principles of the refrigeration cycle to the air conditioning system.

   1. The amount of pressure at the exhaust port of the compressor is determined by the three factors listed below.

      a. The mechanical efficiency of the compressor

      b. The static freon charge pressure of the system

      c. The pressure drop across the expansion valve or orifice tube

   2. The temperature of the freon at the compressor's exhaust port is determined by the two factors listed below.

      a. The amount of heat generated during compression

      b. The amount of heat in the freon

3. The amount of freon pressure at the evaporator inlet is determined by the three factors listed below.

    a. The exhaust pressure of the compressor

    b. The size of the opening in the expansion valve or orifice tube

    c. The system static charge

4. The amount of evaporator outlet pressure is determined by all the factors affecting inlet pressure. Evaporator outlet pressure is also determined by such control devices as EPR, POA, or STV valves.

5. The evaporator temperature is determined by the five factors listed below.

    a. The rate of freon evaporation within the evaporator

        (NOTE: The rate of evaporation is influenced by two factors: the difference between the temperature of the freon and the temperature of the passenger compartment air; the ratio of pure freon to air or oil mixed in the freon may also affect evaporator temperature.)

    b. The static charge of the system

    c. The temperature and rate of air flow across the evaporator

    d. The rate of freon flow into and out of the evaporator

    e. The amount of heat gained from the evaporator heat exchange process.

6. The freon must enter and leave the compressor in the form of a gas or the compressor will be damaged.

C. Interpreting air conditioning performance data

1. When servicing an air conditioning system, observe the items listed below. Results of these observations should be recorded and compared to the manufacturer's specifications.

    a. High and low pressure

    b. Stability of gauge needles

    c. Evaporator temperature

    d. Ambient temperature

    e. The presence of frost on lines

    f. Freon flow (as observed through sight glass, if available)

    g. Difference in temperature between the inlet and outlet tubes of the evaporator, condenser, and accumulator.

        (NOTE: The temperature difference between inlet and outlet tubes of the evaporator, condenser, and accumulator can be determined by touch.)

2. Below is a list of characteristics of an air conditioning system that is functioning properly.

   a. The temperature of the outlet evaporator hose should be significantly higher than that of the inlet evaporator hose. The high/low pressure should fall within an acceptable range. The gauge needles should be stable and cycling.

      (NOTE: For each air conditioning system, there should be a chart that indicates the acceptable high/low pressure range.)

   b. The temperature of the outlet condenser hose should be significantly lower than that of the inlet condenser hose. Air should flow easily across the coils. Pressure should not be measured before and after the condenser.

      (**CAUTION:** At times the inlet line to the condenser can be hot enough to cause second-degree burns.)

   c. There should be no temperature change across the drier. The sight glass (if available) should be clear. The drier should be free of frost and warm to the touch.

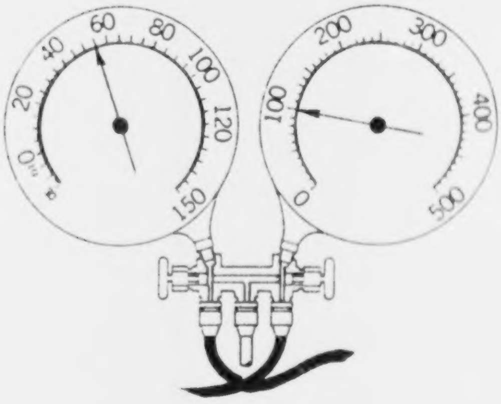
   d. The expansion valve should be free of frost. The temperature of the inlet expansion valve port should be significantly higher than that of the outlet port when the compressor is cycled on. When the compressor is cycled off, the temperature of both ports should be equal.

      (NOTE: Frost should not be on the equalization line or the oil bleed line of equalizing expansion valves.)

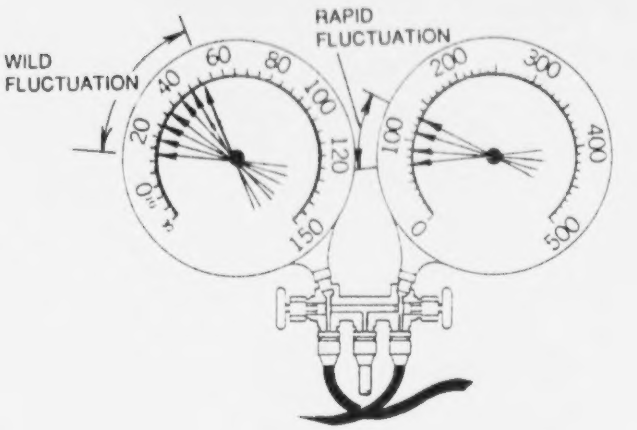
   e. The evaporator's temperature should be within manufacturer's specifications. If equipped with an outlet control device (EPR or POA), the gauge reading should fall within performance specifications of the EPR or POA.

3. The illustrations below depict usual gauge readings for both expansion valve and cycling-clutch orifice tube air conditioning systems. The gauge readings cover a variety of situations.

   a. The below gauge reading indicates drive belt problems.

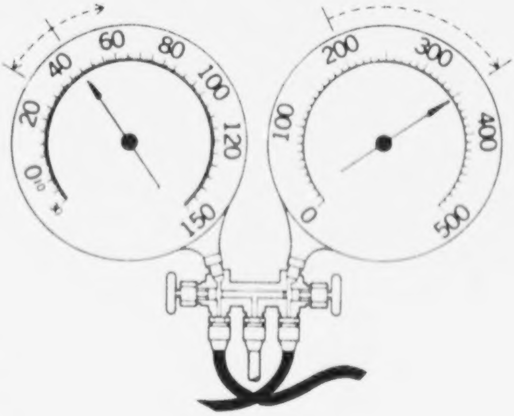


b. The gauge reading below indicates compressor failure.



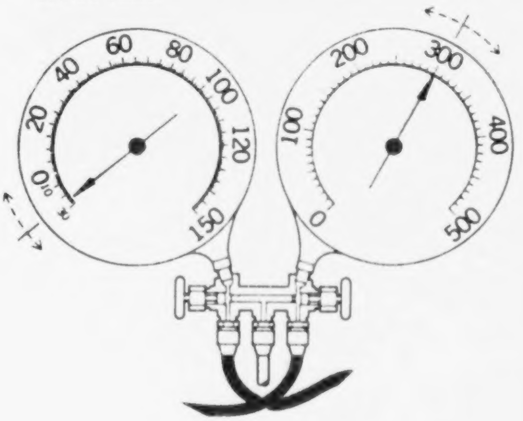
WILD FLUCTUATION
RAPID FLUCTUATION
0
20
40
60
80
100
120
150
0
100
200
300
400
500

c. The gauge reading below indicates compressor failure or system overcharge.



0
20
40
60
80
100
120
150
0
100
200
300
400
500

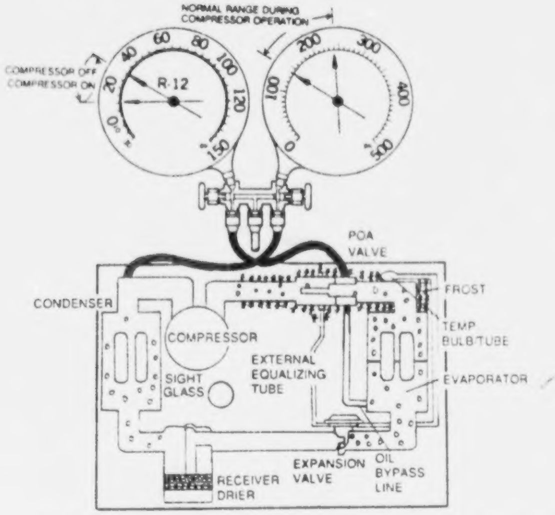
d. The gauge reading below indicates a plugged receiver drier or a plugged orifice tube.



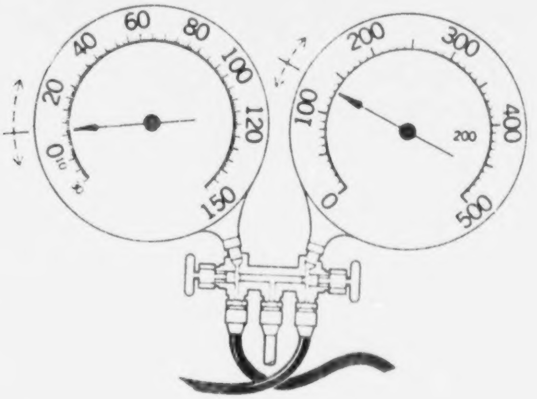
0
20
40
60
80
100
120
150
0
100
200
300
400
500

4. The illustrations below depict typical gauge readings for expansion valve air conditioning systems. The gauge readings cover a variety of situations.

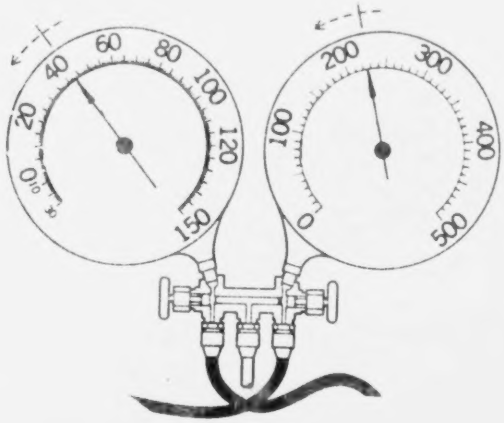
   a. The below gauge reading indicates normal operation of an expansion valve air conditioning system.


NORMAL RANGE DURING COMPRESSOR OPERATION
COMPRESSOR OFF
COMPRESSOR ON
R-12
0
20
40
60
80
100
120
150
0
100
200
300
400
500
POA VALVE
FROST
CONDENSER
TEMP BULB/TUBE
COMPRESSOR
EXTERNAL EQUALIZING TUBE
SIGHT GLASS
EVAPORATOR
EXPANSION VALVE
OIL BYPASS LINE
RECEIVER DRIER

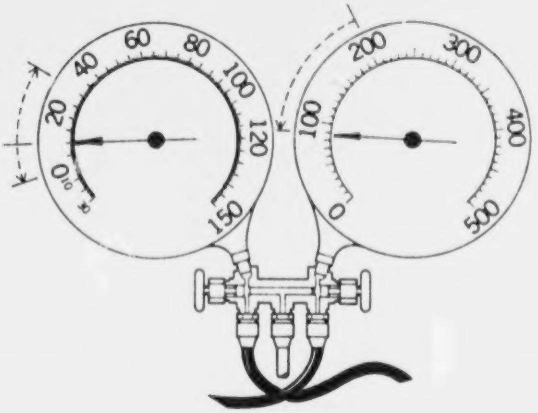
   b. The gauge reading below indicates that an expansion valve is stuck in the open position.


0
20
40
60
80
100
120
150
0
100
200
300
400
500
200

   c. The gauge reading below indicates that an expansion valve is stuck in the closed position.

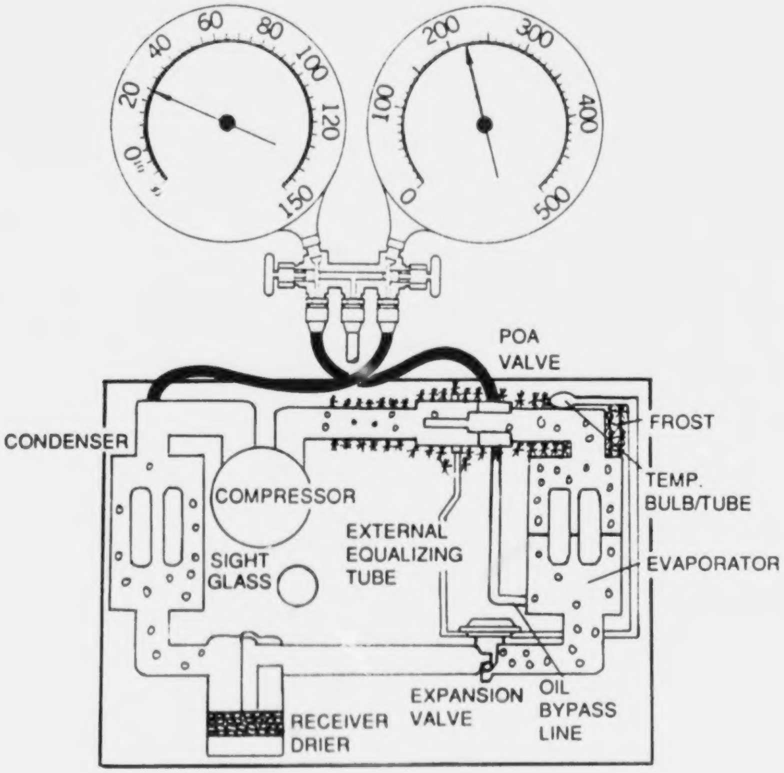

0
20
40
60
80
100
120
150
0
100
200
300
400
500

d. The gauge reading below indicates a low refrigerant charge in an expansion valve system.

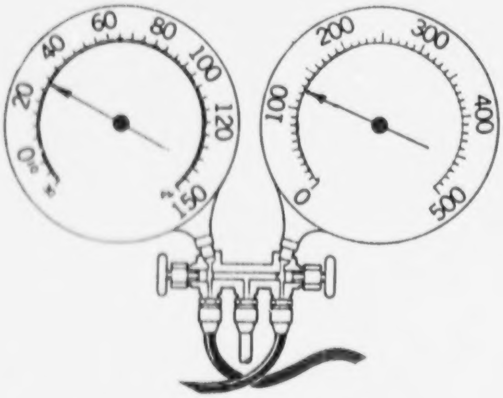

0
20
40
60
80
100
120
150
0
100
200
300
400
500

5. The illustrations below depict typical gauge readings for expansion valve air conditioning systems with either POA or EPR valves. The gauge readings cover a variety of situations.

a. The gauge reading below indicates that a POA valve is stuck in the open position.

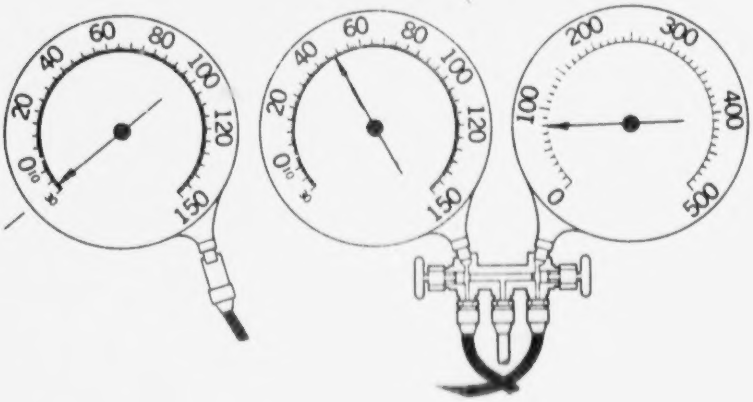

0
20
40
60
80
100
120
150
0
100
200
300
400
500
POA VALVE
FROST
CONDENSER
TEMP. BULB/TUBE
COMPRESSOR
EXTERNAL EQUALIZING TUBE
EVAPORATOR
SIGHT GLASS
EXPANSION VALVE
OIL BYPASS LINE
RECEIVER DRIER

b. The gauge reading below indicates that a POA valve is stuck in the closed position.



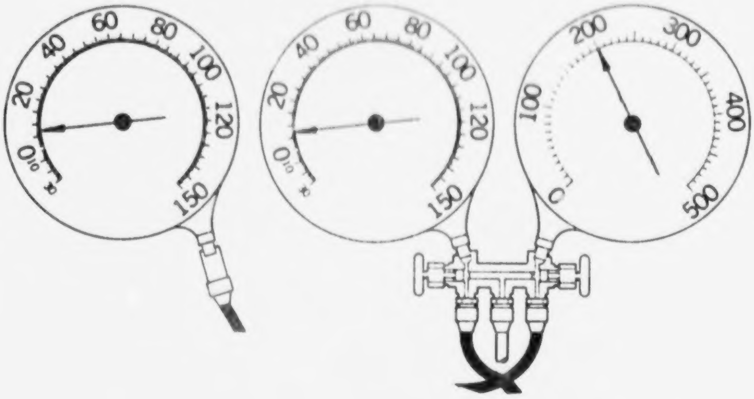
0
20
40
60
80
100
120
150
0
100
200
300
400
500

c. The gauge reading below indicates that an EPR valve is stuck in the closed position.



0
20
40
60
80
100
120
150
0
20
40
60
80
100
120
150
0
100
200
300
400
500

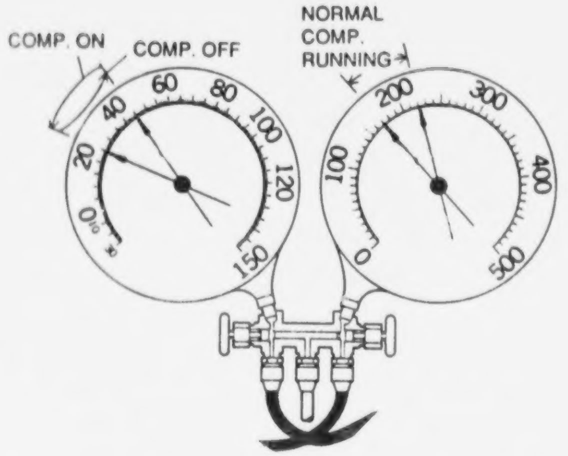
d. The gauge reading below indicates that an EPR valve is stuck in the open position.



0
20
40
60
80
100
120
150
0
20
40
60
80
100
120
150
0
100
200
300
400
500

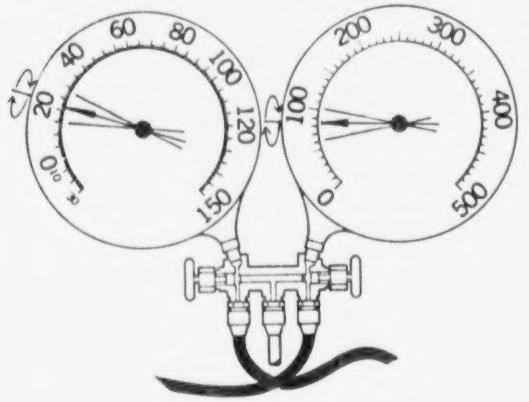
6. The illustrations below depict typical gauge readings for cycling-clutch orifice tube air conditioning systems. The gauge readings cover a variety of situations.

a. The gauge reading below indicates normal operation of a cycling-clutch orifice tube system.



COMP. ON
COMP. OFF
NORMAL
COMP.
RUNNING
0
20
40
60
80
100
120
150
0
100
200
300
400
500

b. The below gauge reading indicates a low freon charge in a cycling-clutch orifice tube system.

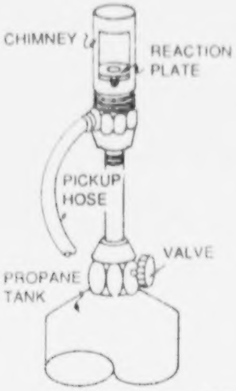


0
20
40
60
80
100
120
150
0
100
200
300
400
500

D. Testing the air conditioning system for leaks

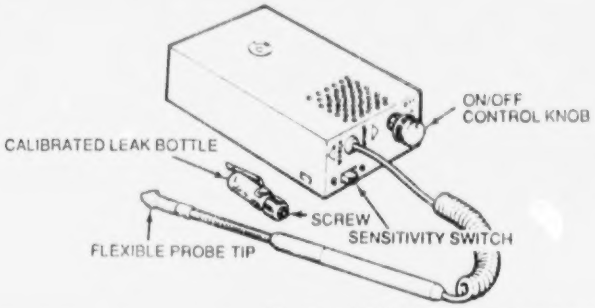
1. A propane (halide) torch leak tester contains a reaction plate made of copper. When heated, the plate causes a flame to change color if freon is present. A pickup hose leading to the flame is passed beneath the various points in the air conditioning system. The flame will change from pale blue to yellow to indicate a small leak or from pale blue to violet to indicate a large leak.

   (**CAUTION:** The propane leak tester poses a significant fire risk if it comes into direct contact with freon gas. Deadly fumes will also be given off if the propane leak tester directly contacts freon. Use extreme caution when operating the propane leak tester.)



Courtesy of Mitchell Information Services, Inc.

2. The electronic leak detector is a battery-powered device with a probe that can detect the presence of freon. If the probe senses freon, an alarm sounds in the detector. Unlike the propane torch leak tester, the electronic detector can be used while the vehicle's engine is running. The electronic tester is also more sensitive than the propane tester and can detect very small leaks.



Courtesy of Mitchell Information Services, Inc.

3. Procedure for using a propane leak tester

   a. Start vehicle engine and put the air conditioner on the maximum setting.

   b. Light propane flame on the leak detector. Adjust the flame till it barely touches the reaction plate.

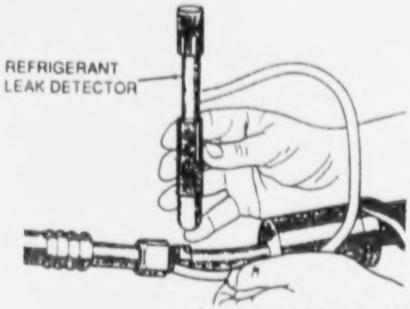
   c. Turn off vehicle engine.

   d. When the reaction plate on the tester becomes cherry red, pass the sample tube beneath the compressor shaft seal. A change in the color of the detector's flame indicates the presence of freon.

e. Pass the sample hose beneath all fittings and hoses that run through the condenser and the receiver-drier. Then pass the hose beneath the expansion valve and orifice tube. The evaporator's condensate drain should also be checked for evaporator leaks. Oil stains or dirt build-up around fittings may indicate leaks in the drain.

(NOTE: Freon is heavier than air; therefore, always pass the sample hose beneath the areas where leaks are suspected.)

(**CAUTION:** Before testing for leaks, make sure the system contains some freon. If the gauge set indicates no static charge before testing, add some freon to the system.)



Courtesy of Chrysler Motors Corporation

4. Procedure for using an electronic leak tester

a. Start engine and put air conditioner on maximum setting.

b. Turn on the tester and calibrate it according to the procedure outlined by the manufacturer.

c. Pass the pickup tube under the air conditioning system components in the appropriate manner.

III. Servicing the air conditioning system

A. Discharging freon from the system

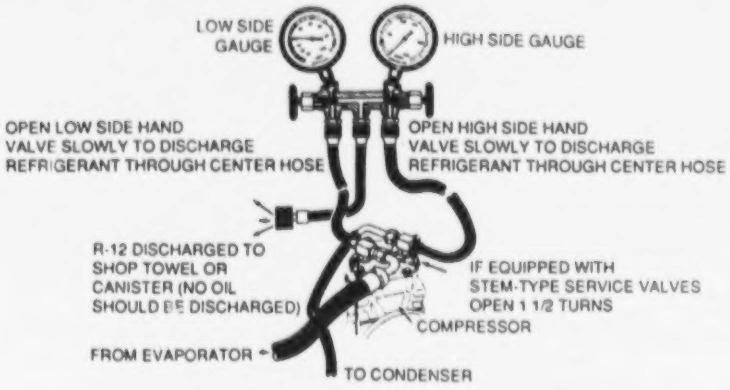
1. Discharging systems that do not use an accumulator

a. With vehicle engine off, attach manifold gauge set.

b. Put center manifold hose into a container or shop rag.

c. Slowly open the low-side hand valve and check the container or shop towel for the presence of oil. If oil is found, reduce discharge rate.

d. Continue discharging until the system's low side is empty. Slowly open the high-side hand valve and let the system finish discharging.



LOW SIDE GAUGE
HIGH SIDE GAUGE
OPEN LOW SIDE HAND VALVE SLOWLY TO DISCHARGE REFRIGERANT THROUGH CENTER HOSE
OPEN HIGH SIDE HAND VALVE SLOWLY TO DISCHARGE REFRIGERANT THROUGH CENTER HOSE
R-12 DISCHARGED TO SHOP TOWEL OR CANISTER (NO OIL SHOULD BE DISCHARGED)
IF EQUIPPED WITH STEM-TYPE SERVICE VALVES OPEN 1 1/2 TURNS
COMPRESSOR
FROM EVAPORATOR
TO CONDENSER

ADJUSTING MANIFOLD GAUGE SET HAND VALVES FOR DISCHARGING NON-ACCUMULATOR TYPE A/C SYSTEM

Courtesy of Mitchell Information Services, Inc.

2. Discharging systems that use an accumulator

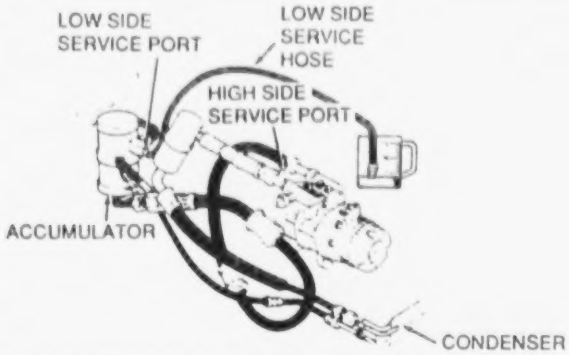
   a. Connect a service hose to the system's low-pressure connection and slowly allow freon to discharge into a measuring cup.

      (**CAUTION:** If no freon is released, the system may be empty. The absence of freon in the system could be the result of a leak.)

   b. When the system's low side is empty, slowly attach a service hose to the high-side fitting. The presence of pressure in the system's high side could indicate a plugged orifice tube or damaged Schrader valve.

3. Check the accumulator for frost. If frost is present, warm the accumulator to release trapped freon.

4. Record the amount of oil captured in the measuring cup. The amount of oil that was captured must be replaced with the same amount of new oil before recharging the system.



LOW SIDE SERVICE PORT
LOW SIDE SERVICE HOSE
HIGH SIDE SERVICE PORT
ACCUMULATOR
CONDENSER

HOSE CONNECTIONS FOR DISCHARGING ACCUMULATOR TYPE A/C SYSTEM (FORD SYSTEM SHOWN)

Courtesy of Mitchell Information Services, Inc.

B. In many cases, replacement of air conditioning system components requires that oil be added to the system. The guidelines listed below indicate how much oil should be added after replacing specific components.

(NOTE: If a major oil loss occurs before, after, or during component replacement, more oil will have to be added.)

1. After condenser replacement, add 1 ounce of oil.

2. After receiver-drier replacement, add 1 ounce of oil.

3. After accumulator replacement, add 1 ounce of oil plus the amount drained during the removal of the old accumulator.

4. After evaporator replacement, add 3 ounces of oil.

5. After valve-in-receiver (VIR) replacement, add 1 ounce of oil plus the amount drained during the removal of the old VIR.

C. Checking and replacing compressor oil

(**CAUTION:** Do not remove drain plug from compressor unless system is discharged.)

1. Refrigerant oil circulates with the freon throughout the air conditioning system. The compressor, however, contains more oil than any other part of the system. The compressor needs refrigerant oil in order to function properly. Checking compressor oil is an important part of air conditioning service.

   (NOTE: Procedures for checking compressor oil vary widely. Only a general procedure is outlined below. Some compressors do not have the service ports needed for checking oil. Refer to a service manual for the exact procedure needed for the compressor being serviced.)

2. Procedure for checking compressor oil

   a. Use only clean refrigerant oil and an appropriate dipstick.

   b. Place the compressor into the position indicated by the service manual, and loosen the oil-check plug.

      (**CAUTION:** Do not remove drain plug from compressor unless system is discharged.)

   c. Insert the dipstick into the appropriate service port; then remove and note oil level

3. Procedure for determining how much oil to add to the compressor after compressor replacement.

   (NOTE: Only a general procedure is outlined below. Refer to a service manual for the exact procedure needed for specific compressors.)

   a. Drain and measure the oil from the compressor that is being removed.

   b. Drain and measure the oil from the compressor that is to be installed.

   c. Make sure the new compressor contains either the same amount of oil as the old compressor or the amount specified by the manufacturer or supplier. Oil may have to be added to or removed from the new compressor in order to ensure amounts are the same.

      (NOTE: Add only new oil to the compressor.)

4. Procedure for manually adding oil to the compressor

    a. Make sure air conditioning system is discharged before adding oil to compressor.

    b. Fill compressor with clean oil through the check hole.

5. Procedure for drawing oil into the compressor with a vacuum pump

    a. Connect low hose to the air conditioning system.

    b. Place one end of oil fill hose into a container holding the correct type of oil. Measure with an auxiliary shut off valve.

    c. Connect a vacuum pump to the center hose.

    d. Start vacuum pump and open auxiliary valve.

    e. Draw oil from measured container. When container makes a gurgling sound, close the auxiliary valve.

    f. Turn off vacuum pump and disconnect oil lines.

6. Procedure for using a pressurized oil can to add oil to the compressor

    a. Connect pressurized oil can to high-side line.

    b. Open high-side valve and add oil to compressor.

    c. Disconnect oil change container.

D. Charging the air conditioning system with freon

1. Procedure for completely charging system (vapor charging)

    a. Check compressor oil.

    b. Evacuate any air from the system. (Refer to a service manual for proper procedure.)

    c. Connect freon container to gauge set.

    d. Purge the center service hose.

    e. Open the low-side hand valve.

    f. When the gauge readings stop rising, close the low valve.

    g. Make sure high-side hand valve is closed.

    h. Start the vehicle's engine, roll down the windows, and place the air conditioner on maximum-high fan.

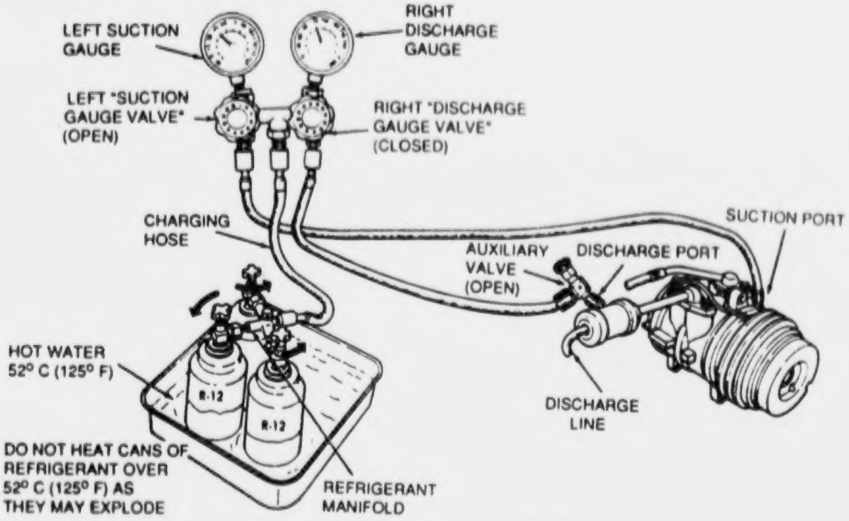
    (NOTE: On systems with a low-charge protector, bypass the connector to engage the compressor clutch.)

i. Open the low-side hand valve until all freon containers are empty or the correct amount is added.

(NOTE: Immersing freon containers into warm water increases low-side pressure which in turn increases the rate-of-charge.)

j. Close low-side valve.

k. Perform system stabilization check.


LEFT SUCTION GAUGE
RIGHT DISCHARGE GAUGE
LEFT "SUCTION GAUGE VALVE" (OPEN)
RIGHT "DISCHARGE GAUGE VALVE" (CLOSED)
CHARGING HOSE
SUCTION PORT
AUXILIARY VALVE (OPEN)
DISCHARGE PORT
HOT WATER 52° C (125° F)
R-12
R-12
DISCHARGE LINE
DO NOT HEAT CANS OF REFRIGERANT OVER 52° C (125° F) AS THEY MAY EXPLODE
REFRIGERANT MANIFOLD

Courtesy of Chrysler Motors Corporation

(**CAUTION:** Refrigerant cans may explode if heated over 52°C or 125°F.)

2. Procedure for completely charging a cycling-clutch orifice tube system (liquid charging)

   a. Check refrigerant oil in system.

   b. Evacuate system.

   c. With the engine off, liquid charge the accumulator by inverting the charge can and opening the low hand valve.

   d. Turn on the engine and place the can in an upright position.

3. Procedure for partially charging system

   a. Connect gauge set and stabilize system.

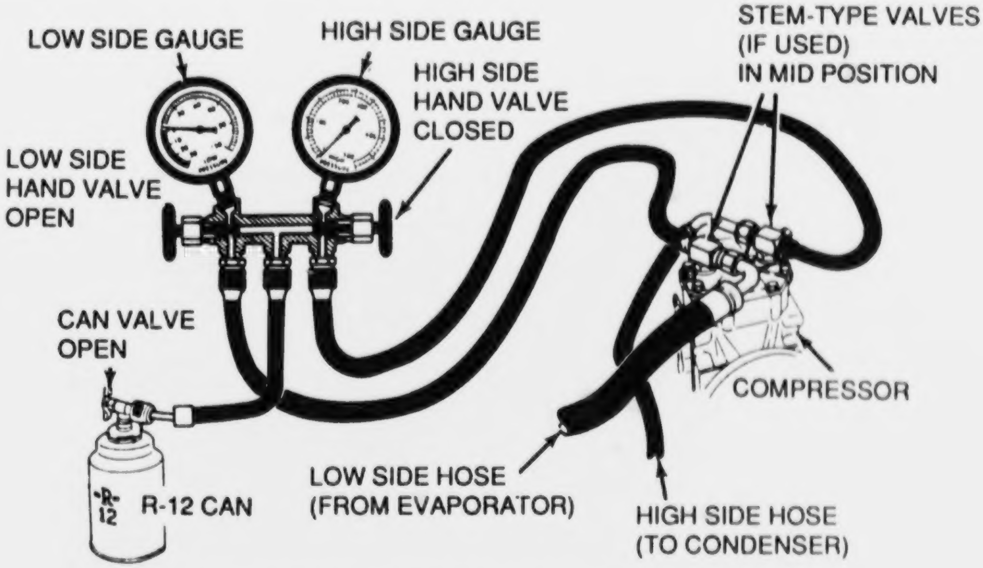
   b. If the system is very low on charge, perform a leak test (see leak test).

   c. If no leak is detected, connect charge can to middle hose and purge the center service hose.

   d. Start the vehicle's engine and operate the air conditioner at the maximum setting.

e. Open low hand valve and charge system until current pressure\temperature parameters are met.

(CAUTION: While engine is running, charge system with vapor freon only.)


LOW SIDE GAUGE
HIGH SIDE GAUGE
HIGH SIDE HAND VALVE CLOSED
STEM-TYPE VALVES (IF USED) IN MID POSITION
LOW SIDE HAND VALVE OPEN
CAN VALVE OPEN
COMPRESSOR
R-12
R-12 CAN
LOW SIDE HOSE (FROM EVAPORATOR)
HIGH SIDE HOSE (TO CONDENSER)

CONNECTIONS FOR ADDING REFRIGERANT TO LOW SIDE OF NON-ACCUMULATOR TYPE SYSTEMS

Courtesy of Mitchell Information Services, Inc.

MODULE: HEATING AND AIR CONDITIONING

SERVICING COMPONENTS OF THE AUTOMOTIVE AIR CONDITIONING SYSTEM

Instructions: Do the following tasks and answer the following questions. Write all responses on this sheet.

1. Define the terms listed below:

Charge

Compound gauge

Discharge

Evacuate

Flush

High side

Leak detector

Manifold gauge set

Performance test

Sight glass

Vacuum pump

2. Name four major dangers inherent in handling freon and describe a way to avoid each.

3. List the parts of a manifold gauge set.

4. Describe two types of air conditioning service ports and explain how they are used.

5. List two types of leak-detection equipment.

6. Name three major kinds of equipment for charging an automotive air conditioning system with freon.

7. Explain how refrigerant oil is added to a charged air conditioning system.

8. What areas of the vehicle must be inspected or tested before conducting a performance test of the air conditioning system?

9. What protection should a technician wear when connecting a service gauge set?

10. List the basic steps in connecting a gauge set.

11. What is an acceptable static charge of freon?

12. Describe how an air conditioning system is stabilized.

13. List four factors that affect compressor output pressure.

14. List three major factors that affect evaporator temperature.

15. List one factor affecting evaporator pressure.

16. Explain the difference between the procedures for discharging a nonaccumulator and an accumulator air conditioning system.

17. List the oil replacement schedule for each component listed below:

Condenser

Receiver-drier

Accumulator

Evaporator

VIR

18. After compressor replacement, how much oil is added to the newly installed compressor?

19. When may liquid freon be used to recharge a CCOT system?

20. Is freon heavier or lighter than air?

MODULE: HEATING AND AIR CONDITIONING

SERVICING COMPONENTS OF THE AUTOMOTIVE AIR CONDITIONING SYSTEM

(ANSWER SHEET)

1. A charge is an amount of freon measured by weight.

   A compound gauge is a pressure and vacuum gauge used on the low-side of the manifold gauge set.

   When an air conditioning system is discharged, pressurized freon is allowed to escape through a valve or opening in the air conditioning system.

   During evacuation, all air, freon, and moisture is eliminated from the air conditioning system.

   To flush an air conditioning system means to purge it of solid contaminants.

   The high-side of an air conditioning system runs from the compressor outlet to the expansion valve.

   A leak detector is a gas or electronic device that indicates a freon leak in the air conditioning system.

   A manifold gauge set is a device for servicing air conditioning systems. The manifold gauge set has gauges and connecting hoses for diagnosing the air conditioning system.

   A performance test measures optimum air conditioning system operation against acceptable system pressures and temperatures.

   A sight glass is a service window through which freon flow can be observed.

   A vacuum pump is a device that evacuates air, freon, and moisture from the air conditioning system.

2. Freon can cause blindness if it contacts the eyes. Freon can also freeze exposed skin. Wearing glasses and protective clothing will minimize these dangers.

   Freon will displace air in a closed environment and, therefore, may cause asphyxiation. Proper ventilation will minimize this danger.

   Freon can form toxic gas if it contacts open flame. Keeping freon away from open flame will minimize this danger.

Freon containers (and air conditioning systems) can burst, causing freon and sharp pieces of metal to fly through the air. This danger can be minimized by carefully monitoring freon pressure and keeping freon containers away from extreme heat.

3. Manifold
   Low and high pressure gauges
   Isolation valves
   Three hoses
   Service connections

4. One type of service port is the Schrader valve. It has a depressor pin that must be pushed to open the system.

   Another type of service port is the stem valve, which has three operating positions.

5. Propane (halide) leak detector
   Electronic leak detector

6. Flat seal
   Screw seal
   Charging system

7. An oil injection tool is used to add refrigerant oil to the air conditioning system.

8. Cooling system
   Air flow system
   Under-hood area

9. Safety glasses or goggles

10. Remove service caps
    Connect high and low-side hoses (close manifold valves)
    Purge the gauge set
    Check for static gauge reading

11. A static charge of freon is acceptable if it equals ambient temperature in pounds per square inch.

12. The engine is run at high speed. Air is blown into the condenser. The air conditioning is put on the maximum setting and allowed to operate for ten minutes with the vehicle windows and doors open. A thermometer is used to determine the temperature of the condenser air flow and the temperature of the air conditioning outlets. Freon flow is observed through the sight glass.

13. Compressor efficiency
    Static freon charge
    Pressure drop across expansion valve

14. The rate of freon evaporation
    Static charge
    Temperature
    Rate of freon flow through evaporator
    Amount of heat exchange in the evaporator

    (NOTE: Any three of the above responses constitute an adequate response to item 14.)

15. Compressor exhaust pressure
    Size of expansion valve or orifice tube opening
    Evaporator outlet pressure control devices

16. The accumulator may have to be warmed before it is removed from an accumulator air conditioning system.

    Refrigerant oil must be drained and measured when discharging an accumulator system.

17. Condenser--1 ounce of oil

    Receiver drier--1 ounce of oil

    Accumulator--1 ounce of oil plus the amount measured during oil removal

    Evaporator--3 ounces of oil

    VIR--1 ounce plus amount of oil drained

18. The amount of oil added to the compressor after compressor replacement depends on the design of the compressor. The service manual must be consulted to determine the precise amount.

19. Liquid freon may be used to recharge a CCOT system when engine is not running.

20. Heavier

MODULE: HEATING AND AIR CONDITIONING

PROCEDURE FOR CHECKING COMPRESSOR OIL

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Locate an air conditioning compressor that needs an oil check. Record the make, model, and year of the vehicle in which the compressor is used.
2. Record the make and type of compressor which will receive the oil check.
3. Develop a written procedure for checking the oil in the compressor. (Make sure the procedure is appropriate for the compressor identified in items 1 and 2 above.)

JS1-L1-UIV

MODULE: HEATING AND AIR CONDITIONING

MAKING PRELIMINARY INSPECTIONS OF AN AUTOMOTIVE AIR CONDITIONING SYSTEM

Equipment:

Safety glasses
Belt tension gauge
Coolant freeze point tester
Cooling system pressure tester
Selected vehicle

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Inspect the condition of engine cooling system drive belts. Record observations in the space below. ___ ___ ___ ___

3. Following the procedure outlined below, test the tension of the cooling system drive belts. ___ ___ ___ ___

    a. Use a tension gauge to determine belt tension. Record findings in the space below.

    b. Use a service manual to determine belt tension specifications for the vehicle being serviced. Record these specifications in the space below.

    c. Adjust belts to meet tension specifications.

4. Following the procedure outlined below, test mechanical clutch cooling fan. ___ ___ ___ ___

    a. Inspect clutch for oil deposits. Record observations in the space below.

b. Check the fan clutch for viscous operation. If engine is warm, the fan should be hard to rotate. If engine is cold, the fan should rotate easily. Record observations in the space below.

c. Check the fan bearing by rocking the fan blades. Record observations in the space below.

5. Following the procedure outlined below, test the electrical cooling fan. ____

a. Start vehicle and allow engine to warm up. The cooling fan should come on when the engine reaches a temperature specified by the manufacturer. Record observations in the space below.

b. With the key in the "on" position, put the air conditioner on the maximum setting and the fan on the high setting. The heater fan should now run. Record observations in the space below.

6. Following the procedure outlined below, inspect engine coolant. ____

a. Check engine coolant level. Record observations in the space below.

(NOTE: Coolant level in nonrecovery systems should be 1 to 2 inches below filler neck. In recovery systems, coolant should be even with the full mark.)

b. Check the freeze point of engine coolant with a tester. Record observations in the space below.

c. Using a pressure cap tester, determine system pressure. Compare the finding to pressure specifications in a service manual. Record observations in the space below.

7. Following the procedure outlined below, check the operation of the heater control valve. — — — —

   a. Start vehicle and adjust heater control panel so that the control valve is open.

   b. Observe if the valve moved properly (in accordance with manual air conditioning and heating systems). Record observations in the space below.

8. Inspect condenser and radiator for air flow obstructions. Record observations in the space below. — — — —

9. Make sure the air control door opens and closes in accordance with heater control panel operation. Record observations in the space below. — — — —

10. Check vacuum hose routing on air conditioning controls. Record observations in the space below. — — — —

11. Check for proper engine idle speed control during operation of the air conditioning system. Record observations in the space below. _ _ _ _

12. Inspect air conditioning hoses for refrigerant oil deposits and mechanical damage. Record observations in the space below. _ _ _ _

13. Inspect the area around the air conditioning compressor clutch for refrigerant oil deposits. Record observations in the space below. _ _ _ _

14. Using a freon leak tester, check the system for leaks. Record the observation in the space below. Refer to JS9-L1-UIV for details of this procedure. _ _ _ _

Average of above evaluations* _ _ _ _

(*This average is a partial evaluation for Competency Gg1. Final evaluation for Gg1 will be made at the end of JS9-L1-UIV.)

MODULE: HEATING AND AIR CONDITIONING

PERFORMANCE TESTING THE AUTOMOTIVE AIR CONDITIONING SYSTEM

Equipment:

Standard air conditioning system gauge set
Celsius or Fahrenheit thermometer
Selected vehicle
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Following the procedure outlined below, prepare an automotive air conditioning system for a performance test. ___ ___ ___ ___

   a. Remove the air conditioning system service port caps.

   b. Connect high and low-side gauges to the air conditioning system.

   c. Purge the gauge set.

3. Following the procedure outlined below, conduct a performance test of the automotive air conditioning system. ___ ___ ___ ___

   a. Check static freon charge. Record observations in the space below.

   b. Place electric fan in front of the vehicle to blow the cool air across the radiator and the condenser.

   (NOTE: Static freon charge should be close if not equal to the ambient air temperature of the air conditioning system.)

c. Start engine and stabilize the air conditioning system.

d. Adjust idle speed to high idle.

e. Set air conditioning controls to the maximum high-cool blower speed.

f. Open vehicle windows.

g. Operate air conditioner for ten minutes. Record gauge readings in the space below.

h. Place thermometer into the duct outlet closest to the evaporator. Record evaporator temperature in the space below.

i. Observe freon through sight glass if available. Record observations in the space below.

Average of above evaluations* ____

(*This average is a partial evaluation for Competency Gg1. Final evaluation for Gg1 will be made at the end of JS9-L1-UIV.)

JS3-L1-UIV

MODULE: HEATING AND AIR CONDITIONING

DIAGNOSING THE PERFORMANCE OF THE AUTOMOTIVE AIR CONDITIONING SYSTEM

Equipment:

Diagnostic chart
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Following the procedure outlined below, diagnose the air conditioning system based on the results of a system performance test. ___ ___ ___ ___

    a. Using the chart below, record the results of the air conditioning system performance test conducted in JS2-L1-UIV. Also record performance test specifications for the system being tested.

    (NOTE: Use a manual to determine performance test specifications.)

	Results of Performance Test	Performance Test Specifications
Ambient air temperature	______________	______________
High gauge reading	______________	______________
Low gauge reading	______________	______________
Evaporator outlet temperature	______________	______________
Sight glass observations	______________	______________
Stability of high and low reading	______________	______________

b. Compare performance test readings to specifications in the above chart.

c. Using a trouble-shooting chart, determine the possible causes of any abnormal readings recorded during the performance test. Record these possible causes in the space below.

Average of above evaluations* ____

(*This average is a partial evaluation for Competency Gg1. Final evaluation for Gg1 will be made at the end of JS9-L1-UIV.)

MODULE: HEATING AND AIR CONDITIONING

DISCHARGING A NONACCUMULATOR AIR CONDITIONING SYSTEM

Equipment:

Safety glasses
Standard air conditioning gauge set
Shop rag or empty container

Procedure: Evaluation 3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Following the procedure outlined below, discharge a nonaccumulator air conditioning system. ___ ___ ___ ___

    a. Attach the gauge set to the air conditioning system.

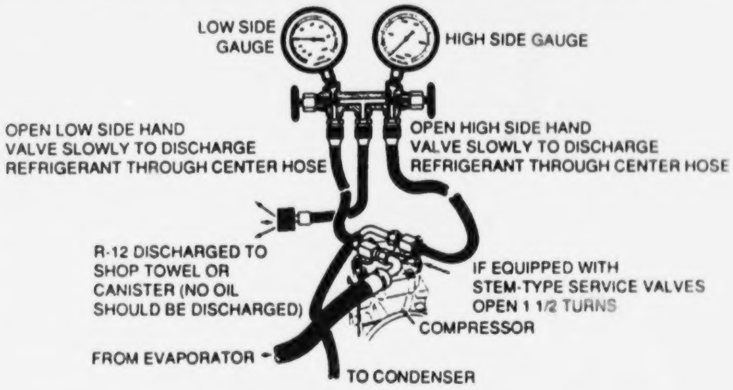
    b. Put shop rag over center hose outlet.

    c. Slowly open the low-side hand valve.

    d. Note the presence of refrigerant oil in the shop rag or container. Reduce discharge rate until no oil is being discharged.

    e. Continue discharging until system pressure is 0 psi.

    f. Open the high-side hand valve and allow the system to empty.


LOW SIDE GAUGE
HIGH SIDE GAUGE
OPEN LOW SIDE HAND VALVE SLOWLY TO DISCHARGE REFRIGERANT THROUGH CENTER HOSE
OPEN HIGH SIDE HAND VALVE SLOWLY TO DISCHARGE REFRIGERANT THROUGH CENTER HOSE
R-12 DISCHARGED TO SHOP TOWEL OR CANISTER (NO OIL SHOULD BE DISCHARGED)
IF EQUIPPED WITH STEM-TYPE SERVICE VALVES OPEN 1 1/2 TURNS
COMPRESSOR
FROM EVAPORATOR
TO CONDENSER

ADJUSTING MANIFOLD GAUGE SET HAND VALVES FOR DISCHARGING NON-ACCUMULATOR TYPE A/C SYSTEM

Courtesy of Mitchell Information Services, Inc.

Average of above evaluations* ___ ___ ___ ___

(*This average is a partial evaluation for Competency Gg3. Final evaluation for Gg3 will be made at the end of JS8-L1-UIV.)

MODULE: HEATING AND AIR CONDITIONING

DISCHARGING AN ACCUMULATOR AIR CONDITIONING SYSTEM

Equipment:

Safety glasses
Standard air conditioning gauge set
Shop rag or empty container

Procedure:	Evaluation 3 2 1 N
1. Wear safety glasses while doing all procedures on this job sheet.	__ __ __ __
2. Following the procedure outlined below, discharge an accumulator air conditioning system.	__ __ __ __

a. Attach gauge set to air conditioning system.

b. Put shop rag over center hose outlet.

c. Slowly open the low-side hand valve.

d. Observe shop rag or container for the presence of refrigerant oil. Reduce discharge rate until no oil is being discharged.

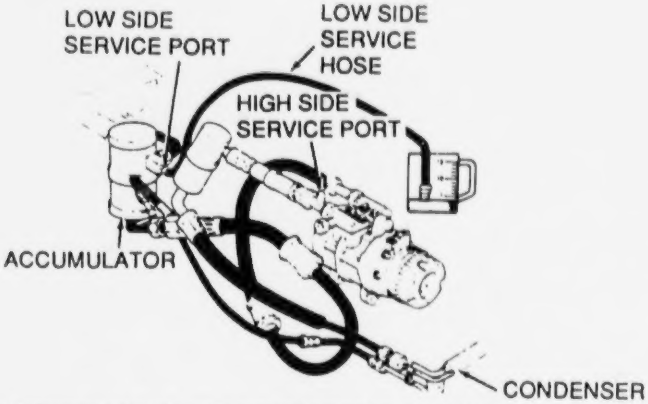
e. Check accumulator for frost.

(NOTE: To defrost an accumulator, either wrap a hot towel around it or place a drop light close to it.)

f. Continue discharging until the system is empty.

g. Open the high-side valve and allow the system to empty.

h. Capture discharged oil in a measuring cup. In the space below, record the amount of oil discharged and the amount of oil that should be added to the system.


LOW SIDE SERVICE PORT
LOW SIDE SERVICE HOSE
HIGH SIDE SERVICE PORT
ACCUMULATOR
CONDENSER

HOSE CONNECTIONS FOR DISCHARGING ACCUMULATOR TYPE A/C SYSTEM (FORD SYSTEM SHOWN)

Courtesy of Mitchell Information Services, Inc.

Average of above evaluations* ____

(*This average is a partial evaluation for Competency Gg3. Final evaluation for Gg3 will be made at the end of JS8-L1-UIV.)

JS6-L1-UIV

MODULE: HEATING AND AIR CONDITIONING

CHECKING COMPRESSOR OIL

Equipment:

Safety glasses
Compressor oil dipstick
Service information
Compressor
Measuring cup
Refrigerant oil
Funnel

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___
2. Following the procedure outlined below, check compressor oil. ___ ___ ___ ___
    a. Complete AS2-L1-UIV.
    b. Using the procedure developed in AS2-L1-UIV, check compressor oil.

Average of above evaluations* ___ ___ ___ ___

(*This average is a partial evaluation for Competency Gg2. Final evaluation for Gg2 will be made at the end of JS5-L1-UVI.)

MODULE: HEATING AND AIR CONDITIONING

EVACUATING AND CHARGING AN AUTOMOTIVE AIR CONDITIONING SYSTEM

Equipment:

Standard air conditioning gauge set
Air conditioning vacuum pump
Freon charge manifold
Service manual
Safety glasses
Scale or charging station (freon weight)
Selected vehicle

(NOTE: If the air conditioning system needs only a partial charge, skip this job sheet and go to JS8-L1-UIV.)

Procedure: Evaluation 3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Confirm that the system is discharged or use the appropriate procedure to discharge the system. ___ ___ ___ ___

3. Perform compressor oil check according to the procedure outlined in JS6-L1-UIV. Record results in the space below. ___ ___ ___ ___

4. Following the procedure outlined below, attach the gauge set and evacuate a nonaccumulator air conditioning system. ___ ___ ___ ___

   (NOTE: If a nonaccumulator system is not available, skip this procedure and go to item 4 of this job sheet.)

   a. Attach vacuum pump to center hose.

   b. Open both hand valves and start pump.

c. For each hour that the system is open, run vacuum pump for twenty minutes. Never pump the system for more than two hours.

d. After the system is evacuated, close hand valves and stop pumping.

e. Observe gauge readings for five minutes. No change in the gauge reading should occur. Record observations in the space below.

f. Connect freon supply to center hose.

g. Purge gauge set.

h. Open low-side hand valve.

i. When the gauge reading stabilizes, close low valve.

j. Make sure that the high-side valve is closed.

k. Open vehicle windows, start engine, and put air conditioner on the maximum setting.

(NOTE: Bypass low-charge protection switch if required.)

l. Open low-side valve, and charge the system until specified weight of freon has been charged. Close valve.

m. Perform system stabilization check.

Average of above evaluations* — — — —

(*The evaluation of either Item 2 or 3 of this job sheet may be omitted from this average. This average is a partial evaluation for Competency Gg3. Final evaluation for Gg3 will be made at the end of JS8-L1-UIV.)

MODULE: HEATING AND AIR CONDITIONING

PARTIALLY CHARGING AN AUTOMOTIVE AIR CONDITIONING SYSTEM

Equipment:

Standard air conditioning gauge set
Freon charge manifold
Service manual
Safety glasses
Selected vehicle
Leak detector

(NOTE: Use this procedure on air conditioning systems that need a partial charge.)

Procedure:	Evaluation 3 2 1 N
1. Wear safety glasses while doing all procedures on this job sheet.	__ __ __ __
2. Following the procedure outlined below, partially charge either an accumulator or nonaccumulator air conditioning system.	__ __ __ __

   a. Connect gauge set and purge gauge set hoses.

   b. Check static pressure. Record observations in the space below.

(NOTE: If static pressure is very low, check system for leaks using a freon leak detector. Record observations in the space below. Refer to JS9-L1-UIV for details of this procedure.)

c. If no leaks are found, connect charging station (manifold) to gauge set.

d. Open vehicle windows, start engine and operate air conditioner at maximum setting.

e. Open low valve until pressure and temperature are correct.

(NOTE: Charge only vapor while engine is running.)

Average of above evaluations* ___ ___ ___ ___

(*This average is a partial evaluation for Competency Gg3. Final evaluation for Gg3 will be made below.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency Gg3 by averaging the evaluations of JS4-L1-UIV, JS5-L1-UIV, JS7-L1-UIV, and JS8-L1-UIV. Use the spaces provided below.

	Evaluation			
	3	2	1	N
JS4-L1-UIV	___	___	___	___
JS5-L1-UIV	___	___	___	___
JS7-L1-UIV	___	___	___	___
JS8-L1-UIV	___	___	___	___
Final evaluation for Competency Gg3	___	___	___	___

JS9-L1-UIV

MODULE: HEATING AND AIR CONDITIONING

TESTING AN AUTOMOTIVE AIR CONDITIONING SYSTEM FOR LEAKS

Equipment:

Propane leak detector
Electronic leak detector
Safety glasses
Ventilation

(NOTE: Depending on the instructor's directions, either item 2 or 3 of this job sheet may be omitted.)

Procedure:	Evaluation 3 2 1 N
1. Wear safety glasses while doing all procedures on this job sheet.	___ ___ ___ ___
2. Following the procedure outlined below, use a propane leak detector to test for leaks in an air conditioning system.	___ ___ ___ ___

(NOTE: If a propane leak detector is not available, skip this procedure and go to item 3 in this job sheet.)

a. Roll down the vehicle's windows, start engine, run air conditioner at maximum setting for 5 minutes, and then turn engine off.

b. Adjust propane detector to appropriate level (red reaction plate).

c. Run the propane detector's sample hose beneath system components. The detector's flame will change color if freon leaks are present. Record observations in the space below.

(**CAUTION:** If freon contacts the propane flame, a toxic gas will be produced. Always ventilate the working area when using a propane leak detector.)

3. Following the procedure outlined below, use an electronic leak detector to test for leaks in an air conditioning system. ___ ___ ___ ___

   (NOTE: If no electronic leak detector is available, skip this procedure and do only item 2 of this job sheet.)

   a. Turn on and calibrate tester according to the procedure provided by the tester's manufacturer.

   b. Roll down the vehicle's windows, start engine, and run air conditioner at maximum setting for five minutes.

   c. Run the electronic detector's probe beneath system components. The detector will make a clicking or buzzing sound if freon leaks are present. Record observations in the space below.

Average of the above evaluations* ___ ___ ___ ___

(*The evaluation for either item 2 or 3 of this job sheet may be omitted from this average. This average is a partial evaluation for Competency Gg1. Final evaluation for Gg1 will be made below.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency Gg1 by averaging the evaluations of JS1-L1-UIV, JS2-L1-UIV, JS3-L1-UIV, and JS9-L1-UIV. Use the spaces provided below.

	Evaluation 3	 2	 1	 N
JS1-L1-UIV	___	___	___	___
JS2-L1-UIV	___	___	___	___
JS3-L1-UIV	___	___	___	___
JS9-L1-UIV	___	___	___	___
Final evaluation for Competency Gg1	___	___	___	___

MODULE: HEATING AND AIR CONDITIONING

UNIT IV: SERVICING THE AUTOMOTIVE AIR CONDITIONING SYSTEM

UNIT IV TEST

PART I. SERVICING THE AIR CONDITIONING SYSTEM

SECTION A. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 1. When discharging a system that does not use an accumulator, the technician should discharge the system's low-side first.

____ 2. If frost is present in an air conditioner's accumulator during discharging, the accumulator should be warmed to release any trapped freon.

____ 3. When recharging an air conditioning system, at least 1 oz of refrigerant oil should always be added to the system.

____ 4. A plugged orifice tube may cause pressure to remain in an accumulator system's high side after the low-side has been discharged.

____ 5. It is seldom necessary to add oil to an air conditioning system after evaporator replacement.

____ 6. After compressor replacement, the new compressor should receive only half the amount of oil that was drained from the old compressor.

____ 7. The air conditioning system should always be discharged before oil is added to the compressor.

____ 8. Refrigerant oil circulates throughout the air conditioning system in small copper tubes.

____ 9. In many cases, replacement of air conditioning system components requires that oil be added to the system.

(NOTE: The student must obtain a minimum score of ____ on Part I of the Unit IV Test in order to receive an evaluation for Competency Gg3.)

PART II. DIAGNOSING AND PERFORMANCE TESTING THE AIR CONDITIONING SYSTEM

SECTION A. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 10. A sound detector is a noise-sensitive electronic instrument that detects the presence of foam or bubbles in an air conditioner's freon stream.

____ 11. The condition of cooling system drive belts should be checked as part of a general inspection of the air conditioning system.

____ 12. The engine cooling fan should run whenever the air conditioning switch is on.

____ 13. An air conditioning system working at a temperature of 70°F would produce a charge pressure of about 35 pounds per square inch.

____ 14. The ambient temperature of an air conditioning system can be determined by holding a thermometer in the air blowing across the system's evaporator.

____ 15. Diagnosis of the refrigeration cycle of an air conditioning system centers upon the relationship between the temperature, the pressure, and the physical state of the freon within the system.

____ 16. The static freon charge pressure of an air conditioning system is partially responsible for determining the amount of pressure at the exhaust port of the compressor.

____ 17. The temperature of freon at the compressor inlet is an important factor in determining the amount of freon pressure at the evaporator inlet.

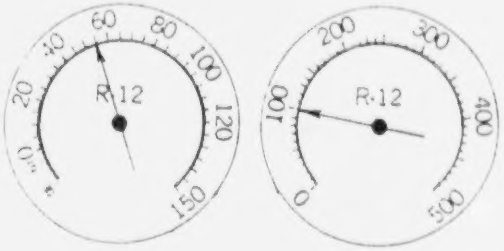
____ 18. The temperature of the evaporator is determined mainly by the temperature of freon in the condenser.

____ 19. Freon enters and leaves the compressor in the form of a liquid.

SECTION B. Select the best answer from the five choices listed.

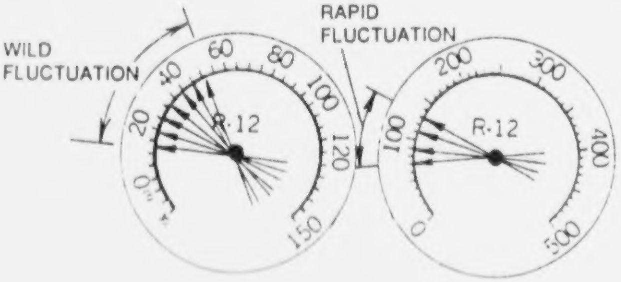
____ 20. The gauge pictured below was taken from an air conditioning system using either an expansion valve or a cycling-clutch orifice tube. The below gauge indicates

a. that the system is functioning normally.
b. that the system's compressor has failed.
c. that the system has either a plugged receiver-drier or a plugged orifice tube.
d. that there is a problem with the system's drive belt.
e. none of the above.



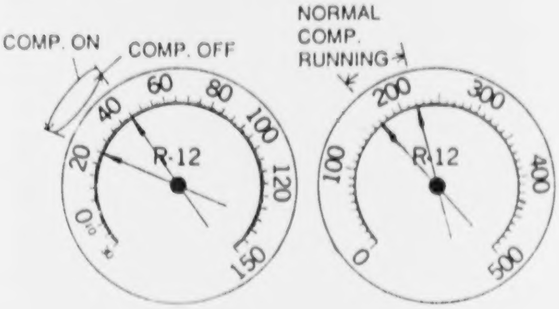
____ 21. The gauge pictured below was taken from an air conditioning system using either an expansion valve or a cycling-clutch orifice tube. The below gauge indicates that the

a. system is functioning normally.
b. system's compressor has failed.
c. system has either a plugged receiver-drier or a plugged orifice tube.
d. system's drive belt is malfunctioning.
e. system's condenser is leaking.



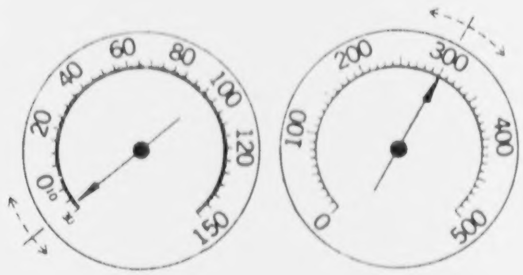
____ 22. The gauge pictured below was taken from an air conditioning system using either an expansion valve or a cycling-clutch orifice tube . The below gauge indicates that the

a. system is functioning normally.
b. system's compressor has failed.
c. system has either a plugged receiver-drier or a plugged orifice tube.
d. system's drive belt is malfunctioning.
e. system's condenser is leaking.


COMP. ON
COMP. OFF
NORMAL
COMP.
RUNNING
0
20
40
60
80
100
120
150
R-12
0
100
200
300
400
500
R-12

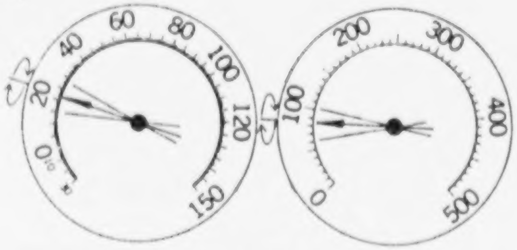
____ 23. The gauge pictured below was taken from an expansion valve air conditioning system. The below gauge indicates that the

a. system is functioning normally.
b. system's expansion valve is stuck in the open position.
c. system's expansion valve is stuck in the closed position.
d. system has a low freon charge.
e. system's condenser is leaking.


0
20
40
60
80
100
120
150
0
100
200
300
400
500

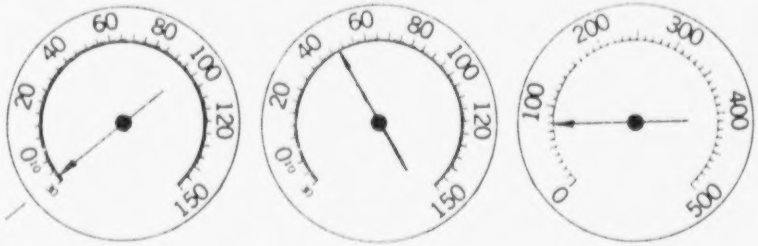
____ 24. The gauge pictured below was taken from an expansion valve air conditioning system. The below gauge indicates that the

a. system is functioning normally.
b. system's expansion valve is stuck in the open position.
c. system's expansion valve is stuck in the closed position.
d. system has a low freon charge.
e. system's condenser is leaking.


0
20
40
60
80
100
120
150
0
100
200
300
400
500

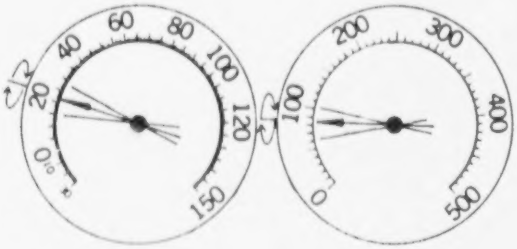
____ 25. The gauge pictured below was taken from an expansion valve air conditioning system, using either a POA or EPR valve. The below gauge indicates that the

a. system is functioning normally.
b. system's POA valve is stuck in the open position.
c. system's EPR valve is stuck in the open position.
d. system's EPR valve is stuck in the closed position.
e. system's freon is flowing too rapidly.


0
20
40
60
80
100
120
150
0
20
40
60
80
100
120
150
0
100
200
300
400
500

____ 26. The gauge pictured below was taken from an cycling-clutch orifice tube air conditioning system. The below gauge indicates that the

a. system is functioning normally.
b. system's compressor has failed..
c. system has a low freon charge.
d. system is overcharged with freon.
e. system's freon is flowing too rapidly.


0
20
40
60
80
100
120
150
0
100
200
300
400
500

___ 27. If a propane leak tester detects freon, the tester's flame will

a. diminish in size.
b. increase in size.
c. change in color.
d. begin to produce sooty, black smoke.
e. produce a sulphur-like odor.

___ 28. During inspection of the air conditioning system, the difference between inlet and outlet temperatures of the evaporator and condenser should be determined by

a. placing a thermometer on the hoses leading out of the evaporator and condenser.
b. placing a thermometer on the hoses leading into the evaporator and condenser.
c. placing a thermometer on the evaporator and condenser.
d. touching the evaporator and condenser with bare hands.
e. gauge readings.

___ 29. If an air conditioning system is functioning properly, the temperature of its evaporator outlet hose should be

a. significantly higher than that of the inlet evaporator hose.
b. only slightly higher than that of the inlet evaporator hose.
c. significantly lower than that of the inlet evaporator hose.
d. only slightly lower than that of the inlet evaporator hose.
e. exactly the same as the inlet evaporator hose.

___ 30. If an air conditioning system is functioning properly, the temperature of its drier should

a. be significantly higher on the inlet side than on the outlet side.
b. be only slightly higher on the inlet side than on the outlet side.
c. be significantly higher on the outlet side than on the inlet side.
d. be only slightly higher on the outlet side than on the inlet side.
e. remain the same across the drier.

(NOTE: The student must obtain a minimum score of _____ on Part II of the Unit IV Test in order to receive an evaluation for Competency Gg1.)

ANSWERS TO UNIT IV TEST

1. t
2. t
3. f
4. t
5. f
6. f
7 t
8. f
9. t
10. t
11. t
12. t
13. f
14. f
15. t
16. t
17. f
18. f
19. f
20. d
21. b
22. c
23. a
24 d
25. d
26. c
27. c
28. d
29. a
30. e

MODULE: HEATING AND AIR CONDITIONING

UNIT V: THE AUTOMOTIVE AIR CONDITIONING COMPRESSOR AND COMPRESSOR CLUTCH

UNIT OBJECTIVE

After completing this unit, the student should be able to service the automotive air conditioning compressor and compressor clutch. The student will demonstrate mastery of the material by achieving a score of ____ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lesson in this unit, the student should be able to:

Lesson 1.

I. Identify terms and definitions associated with servicing an air conditioning compressor and compressor clutch (Competency Gg2, Unit V Test).

II. Identify procedures for inspecting and servicing an air conditioning compressor (Competency Gg2, Unit V Test).

III. Identify procedures for inspecting and servicing an air conditioning compressor clutch (Competency Gg2, Unit V Test).

IV. Identify various types of air conditioning hoses and hose fittings (Competency Gg2, Unit V Test).

V. Demonstrate the ability to:

   a. Replace the shaft seal on an air conditioning compressor (Competency Gg2, JS1-L1-UV).

   b. Replace compressor protection devices (Competency Gg2, JS2-L1-UV).

   c. Replace compressor reed plates (Competency Gg2, JS3-L1-UV).

   d. Replace the compressor clutch (Competency Gg2, JS4-L1-UV).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks G014, G019, G015, G035, and G020.

MODULE: HEATING AND AIR CONDITIONING

UNIT V: THE AUTOMOTIVE AIR CONDITIONING COMPRESSOR AND COMPRESSOR CLUTCH

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

  1. Lesson 1: SERVICING THE AUTOMOTIVE AIR CONDITIONING COMPRESSOR AND COMPRESSOR CLUTCH

    a. Information outline

    b. Assignment sheets

      AS1-L1-UV: Testing and Servicing the Compressor
      AS2-L1-UV: Procedures for Air Conditioning Compressor Shaft Seal Replacement
      AS3-L1-UV: Procedures for Air Conditioning Compressor Disassembly
      AS4-L1-UV: Procedures for Air Conditioning Compressor Clutch Replacement

    c. Job sheets

      JS1-L1-UV: Replacing the Shaft Seal on an Air Conditioning Compressor
      JS2-L1-UV: Replacing Compressor Protection Devices
      JS3-L1-UV: Replacing Compressor Reed Plates
      JS4-L1-UV: Replacing the Compressor Clutch

E. Unit test

F. Answers to unit test

REFERENCES

Carter Carburetor Division, ACF Industries, Inc. Automotive Air Conditioning Theory and Practice.

Mitchell Information Services, Inc. Heating and Air Conditioning Systems. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1987.

Mitchell International, Inc. Automotive Air Conditioning Basic Service Training Manual. 21st ed. San Diego, CA: Mitchell International Inc., 1988.

Mitchell Manuals, Inc. 1984 Edition Automotive Air Conditioning Basic Service Training Manual. San Diego, CA: Mitchell Manuals, Inc., 1984.

Murray Corporation. Dealer Education Program Temperature Control Clinic Workbook. Cockeysville, MD: Murray Corporation, 1988.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Students should do AS1-L1-UV before taking the Unit V Test.
2. Students should do AS2-L1-UV in conjunction with JS1-L1-UV; AS3-L1-UV in conjunction with JS3-L1-UV; AS4-L1-UV in conjunction with JS4-L1-UV.

MODULE: HEATING AND AIR CONDITIONING

UNIT V: THE AUTOMOTIVE AIR CONDITIONING COMPRESSOR AND COMPRESSOR CLUTCH

LESSON 1: SERVICING THE AUTOMOTIVE AIR CONDITIONING COMPRESSOR AND COMPRESSOR CLUTCH

I. Terms and definitions

A. Axial compressor--A compressor with pistons arranged parallel to the shaft.

B. Clutch--A coupling device that connects the compressor drive pulley to the compressor drive shaft.

C. Clutch pulley--The compressor drive pulley. The clutch pulley free wheels when the clutch is disengaged.

D. Compressor cutout switch--A device that disengages the compressor clutch on the basis of low charge, high charge, or temperature within the air conditioning system.

E. Crankshaft--A shaft used to drive compressor pistons.

F. Crankshaft seal--A device that prevents freon from leaking between the front shaft of the crankshaft and case.

G. Feeler gauge--A flat piece of metal used to measure clearances between two surfaces.

H. Field coil--An electrical winding used to pull the compressor flexplate into engagement.

I. Flexplate--The part of a compressor clutch that engages the drive pulley to the compressor drive shaft.

J. In-line compressor--A compressor in which pistons are arranged side by side. The pistons in-line compressors move perpendicular to the crankshaft.

K. Radial compressor--A compressor in which cylinders are arranged so that they radiate from the drive shaft center.

L. Reed valves--Thin metal valves used to provide compressor inlet and outlet valving.

M. Rotary compressor--A compressor that uses either rotating vanes or a rotor to pump freon.

N. Superheat switch--A compressor cutout device which throws the thermal fuse when the freon charge within the air conditioning system becomes too low.

O. Thermal limiter--A fuse device that opens when it is grounded by the superheat switch.

II. Compressor service

A. Compressor shaft seal

(NOTE: The compressor shaft seal is very vulnerable to freon leaks.)

1. Most compressor shafts use either a lip seal, carbon seal, or ceramic seal.

a. Lip seals have a garland spring that maintains pressure on the seal.

b. Carbon and ceramic seals have highly polished surfaces. When lubricated with refrigerant oil, freon cannot escape between the mating surfaces. Failure of carbon and ceramic seals is most often caused by dirt and scorching. A spring device maintains constant pressure on the seal surface.

2. Procedure for replacing compressor shaft seals

(NOTE: Outlined below is a general procedure for replacing compressor shaft seals. The procedure will vary depending on the type of compressor being serviced. Always consult a service manual to find the appropriate procedure.)

(NOTE: Before the seal can be replaced, the flexplate must be removed. The flexplate is press-fitted to the shaft and, therefore, must be removed with a special puller.)

a. Discharge system according to standard procedure.

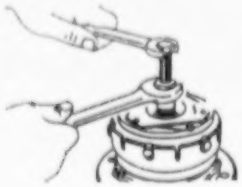
b. Clean the flexplate area with solvent and blow it dry with compressed air.

c. Using a special flexplate holder tool, remove shaft nut.

(**CAUTION:** Failure to discharge the system prior to removal of the flex plate may result in injury to the technician or damage to the component.)

d. Remove snap ring and washer.

e. Remove clutch flexplate using a special puller.



Courtesy of General Motors Corporation

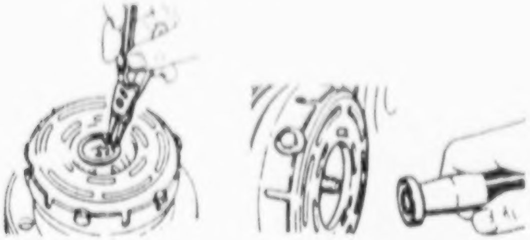
(NOTE: On some vehicles the compressor may have to be removed before the seal is replaced.)

f. Remove shaft seal snap ring.

g. Using a special tool, remove shaft seal seat.

h. Using special puller, remove shaft seal.

i. Remove shaft seal o-rings.



Courtesy of General Motors Corporation

j. Replace shaft seal by reversing disassembly procedures. Use refrigerant oil as an assembly lubricant.

(NOTE: Special care should be taken to keep all seal components clean during assembly.)

3. Procedure for leak testing seal

(NOTE: Some compressors can be leak tested before reinstallation of the flexplate.)

a. Rotate compressor shaft several times to seat seal.

b. Attach a manifold gauge set to the fittings on the compressor or the compressor test adaptor.

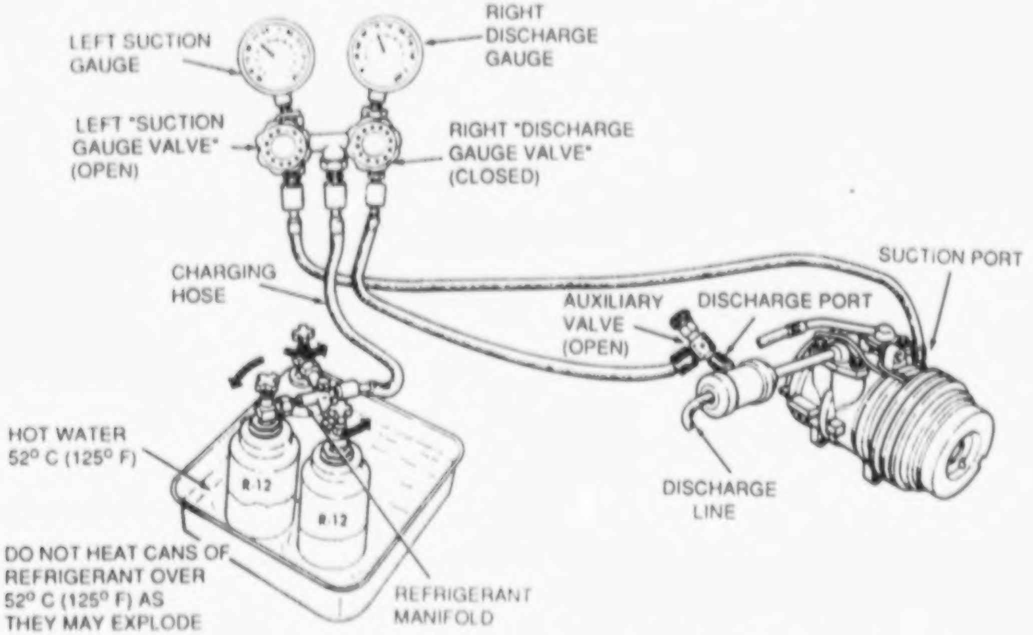
c. Purge gauge assembly.

d. Charge the compressor with freon.

e. Shut off the supply of freon to the compressor.

(**CAUTION:** If refrigerant cans are heated to over 52°C or 125°F, they may explode.)

f. Monitor the gauge set for several minutes to determine if the compressor is capable of holding a charge. If the compressor loses any charge, use a leak detector to determine the location of the leak.


LEFT SUCTION GAUGE
RIGHT DISCHARGE GAUGE
LEFT "SUCTION GAUGE VALVE" (OPEN)
RIGHT "DISCHARGE GAUGE VALVE" (CLOSED)
CHARGING HOSE
SUCTION PORT
AUXILIARY VALVE (OPEN)
DISCHARGE PORT
HOT WATER 52° C (125° F)
R-12
R-12
DISCHARGE LINE
DO NOT HEAT CANS OF REFRIGERANT OVER 52° C (125° F) AS THEY MAY EXPLODE
REFRIGERANT MANIFOLD

Courtesy of Chrysler Motors Corporation

B. Compressor system protection devices

1. On some compressors, a high-pressure-relief valve is used to prevent excess operating pressure. If this valve should fail (which it seldom does), replace it according to the procedure outlined below.

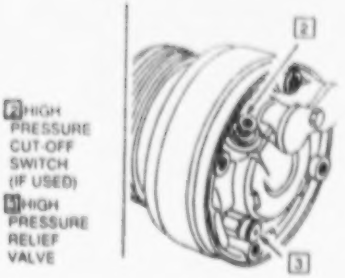
   a. Discharge the system.

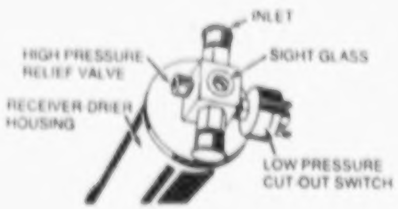
   b. Unscrew relief valve and replace it with a new one.

   c. Check compressor oil level. Substantial oil loss usually occurs when a relief valve fails.

   d. Evacuate air conditioning system.

   e. Recharge air conditioning system.


2
3
2 HIGH PRESSURE CUT-OFF SWITCH (IF USED)
3 HIGH PRESSURE RELIEF VALVE


INLET
HIGH PRESSURE RELIEF VALVE
SIGHT GLASS
RECEIVER-DRIER HOUSING
LOW PRESSURE CUT-OUT SWITCH

Courtesy of General Motors Corporation

2. Superheat or low/high pressure cutout switches protect the system from excess heat and low pressure. To replace one of these switches, follow the procedure outlined below.

   (NOTE: The procedure for replacing superheat or low/high pressure cutout switches is similar to the procedure for replacing pressure-relief valves.)

   a. Discharge the system.

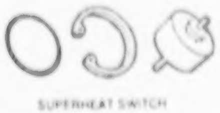
   b. Remove switch snap ring.

   c. Pull switch out.

   d. Remove o-ring.

   e. Replace o-ring and switch.

   f. Evacuate and recharge system.


SUPERHEAT SWITCH

THERMAL LIMITER FUSE

Courtesy of Murray Corporation

C. Procedure for replacing and inspecting reed valves

(NOTE: Reed valves are inspected and replaced as a unit. The compressor must be disassembled before the reed valves can be inspected or replaced.)

1. Discharge the system.

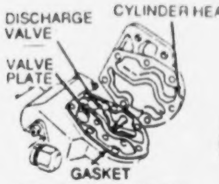
2. Disassemble the compressor according to the manufacturer's procedure.

3. Determine reed valve gap by measuring between the valve plate and the reed valve. The gap should not exceed .010 of an inch. If the gap is greater than .010 of an inch, discard the reed plate.

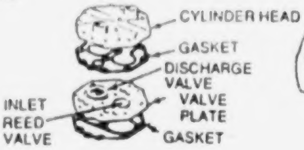
4. Check for and replace dimpled, broken, or missing valve plates.

5. Inspect the plate for burnt compressor oil. Burnt oil will give off a heavy, rancid odor and leave brown stains on the plate. Replace the plate if evidence of burnt oil is found.

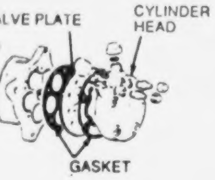
6. To reassemble the plate, reverse the above procedure.


DISCHARGE VALVE
CYLINDER HEAD
VALVE PLATE
GASKET

CHRYSLER 2-CYLINDER


CYLINDER HEAD
GASKET
DISCHARGE VALVE
INLET REED VALVE
VALVE PLATE
GASKET

TECHUMSEH & YORK 2-CYLINDER


VALVE PLATE
CYLINDER HEAD
GASKET

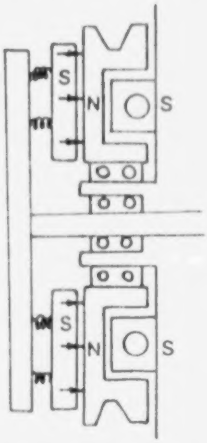
SANKYO 5-CYLINDER

Courtesy of Mitchell Information Services, Inc

III. Compressor clutch service

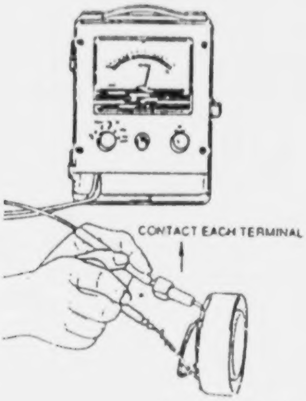
A. Testing the electrical operation of the clutch

1. After passing through a variety of control devices, current from the battery arrives at the compressor's magnetic coil. A magnetic field is created around the coil as the current flows through it.



2. To check for opens in the clutch circuit, perform a resistance test on the coil according to the procedure outlined below.

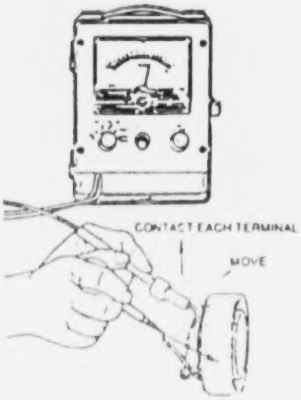
   a. Set the meter to the Rx1 scale and calibrate.
   b. Connect an ohmmeter to each coil terminal lead.
   c. The resistance should be low but not zero. If resistance is high, an open may exist in the clutch circuit.



Courtesy of Ford Motor Company

3. To check for grounds in the clutch circuit, perform a resistance test on the coil according to the procedure outlined below.

   a. Connect one lead of the ohmmeter to the coil terminal.
   b. Connect the other lead to the metal coil casing.
   c. The ohmmeter reading should be infinite on Rx1 scale. If the reading is not infinite, there may be a ground in the clutch circuit.



Courtesy of Ford Motor Company

4. To check for shorts in the clutch circuit, perform a resistance test on the coil according to the procedure outlined below.

   a. Use a service manual to determine fuse size for the compressor clutch circuit.

b. Using Ohm's law, calculate the lowest allowable resistance that would prevent fuse destruction.

c. Connect ohmmeter leads to the coil terminals. The ohmmeter reading should be greater than the calculated resistance reading. If the reading is not greater than the calculated resistance reading, there may be a short in the coil.

B. Procedure for testing the compressor clutch bearing

1. The clutch bearing rotates whether the compressor clutch is engaged or disengaged. Distinguishing between clutch bearing noise and compressor bearing noise can, therefore, be difficult. To determine whether the unusual noise is coming from the compressor bearing or the clutch bearing, follow the procedure outlined below.

   a. Engage compressor clutch while engine is running. Note the level of bearing noise.

   b. Disengage compressor clutch. If the noise stops or changes, there is most likely a problem with the compressor bearing. If the noise persists, there is most likely a problem with the clutch bearing.

   c. Replace the faulty clutch bearing.

C. Procedure for replacing the compressor clutch

(NOTE: Outlined below is a general procedure for compressor clutch replacement. Details of the procedure may vary, depending on the make of the compressor being serviced.)

(**CAUTION:** The system must be discharged before performing the following procedure.)

1. While holding the clutch hub assembly with a clutch spanner wrench, remove the nut from the input shaft with a thin-wall deep socket.

2. Remove clutch hub by screwing the clutch plate and hub remover into the hub. Hold the tool with the wrench and turn the tool's center screw into the tools's body. Remove shaft key.

3. Using snap ring pliers, remove snap ring. Then remove the rotor and bearing assembly. Mark location of clutch coil terminals.

4. Install puller guide and rotor puller. Turn puller clockwise into the slots to engage puller tangs between slots in the rotor. Hold puller in place and tighten puller screw against puller guide to remove pulley rotor and bearing assembly. Take care to support rotor hub properly during bearing removal.

5. Remove rotor.

6. Remove rotor bearing by forcing the bearing out of the rotor hub with a rotor and bearing remover.

   (NOTE: It is not necessary to remove staking to remove bearing. However, old stake metal must be filed away to allow proper clearance for the new bearing.)

7. Install the rotor bearing by supporting the rotor hub with a block. (Make sure the rotor is fully supported.) Align new bearing squarely with hub bore. Use the rotor and a bearing installer to force the bearing into the hub.

8. Stake bearing by placing the bearing staking guide and bearing staking pin into hub bore. Support the rotor and bearing at the under staking pin location. A heavy rubber band may be used to hold stake pin in place. Strike the staking pin with a hammer until a metal stake forms. This stake should extend to a point very near to (but not touching) the bearing. Stake three places 120 degrees apart.

9. With compressor mounted to holding fixture, install the rotor. Using rotor and bearing installer, drive rotor and bearing onto front of the compressor. Install rotor and bearing retaining ring with snap ring pliers.

10. Install clutch plate and shaft key into hub key groove. Make sure to align shaft key with shaft keyway and place clutch plate and hub assembly onto compressor shaft.

    (NOTE: Key should project approximately 3/16" out of keyway.)

    (NOTE: Clutch plate friction surface and clutch rotor should be clean before installing clutch plate and rotor assembly. Install clutch plate and hub installer.)

11. When installing the clutch plate, hold the center portion of the installation tool with a wrench. Tighten hex portion of tool to press hub onto shaft. Air gap between clutch plate and rotor should be .015-.025".

12. Remove installer and make sure that shaft key is even with or slightly above clutch hub. Install shaft nut and torque to specifications.

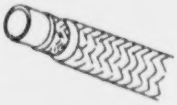
IV. Hoses and seals

A. Hose and hose fittings

1. Air conditioning hoses are made of neoprene tubing. A two-ply rayon reinforcement is wrapped around the tubing for protection and strength. Hoses are sized according to either their internal diameter or a numerical numbering system.

2. Air conditioning hoses are pressure rated. It is extremely important to use only hoses that meet or exceed the vehicle manufacturer's original pressure rating.

3. Air conditioning hoses should never be bent into a tight radius because the tubing is likely to kink or collapse causing a leak.

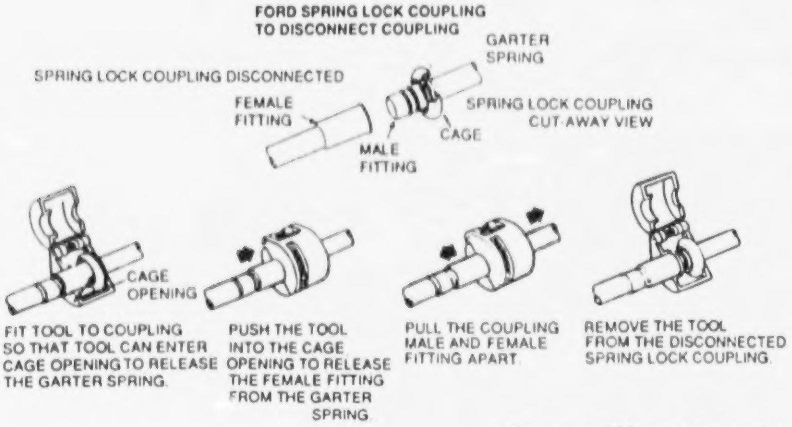


4. Fittings are devices that attach to the ends of air conditioning hoses. By connecting a pair of fittings, two hoses can be joined. A fitting can also be used to connect a hose to another air conditioning component. O-ring fittings are the most common method used to seal connections on air conditioning hoses. However, tapered seat (flare fittings) can also be used to seal hose connections.

   a. An o-ring fitting is made of neoprene or teflon. A flare on the tube of the fitting pushes the seal against a seat. To avoid damage to the seal, the fitting should be lubricated with refrigerant oil during assembly.

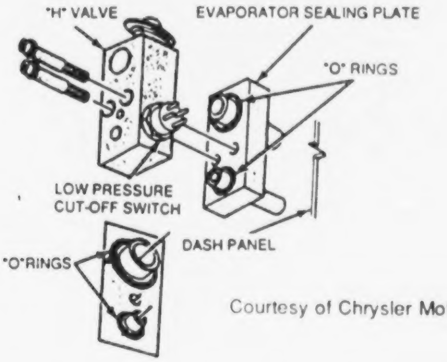
Courtesy of Murray Corporation

b. In some air conditioning systems (primarily Fords) o-ring fittings are joined together with spring-lock couplings. A special locking spring, called a garland, locks the fitting together. O-ring seals (located in the fitting) seal the coupling. These seals should never be reused. A special tool is required to unlock the connection.


FORD SPRING LOCK COUPLING
TO DISCONNECT COUPLING
GARTER SPRING
SPRING LOCK COUPLING DISCONNECTED
FEMALE FITTING
SPRING LOCK COUPLING CUT-AWAY VIEW
CAGE
MALE FITTING
CAGE OPENING
FIT TOOL TO COUPLING SO THAT TOOL CAN ENTER CAGE OPENING TO RELEASE THE GARTER SPRING.
PUSH THE TOOL INTO THE CAGE OPENING TO RELEASE THE FEMALE FITTING FROM THE GARTER SPRING.
PULL THE COUPLING MALE AND FEMALE FITTING APART.
REMOVE THE TOOL FROM THE DISCONNECTED SPRING LOCK COUPLING.

Courtesy of Murray Corporation

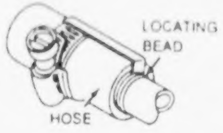
c. Another type of o-ring fitting is the flange fitting. Flange fittings have flat shoulders that are sealed either by o-rings or compression gaskets.


"H" VALVE
EVAPORATOR SEALING PLATE
"O" RINGS
LOW PRESSURE CUT-OFF SWITCH
DASH PANEL
"O"RINGS

Courtesy of Chrysler Motors Corporation

5. Another type of fitting (other than the o-ring) is the flare fitting, also referred to as a tapered seat fitting. The flare fitting is getting increasingly more use in automotive air conditioning systems. Flare fittings have tapered seats, which mate together to seal the surfaces between fittings.

6. Sometimes air conditioning hoses can be clamped or crimped together without a fitting. In other instances, fittings can be joined together by a clamp or crimper. When a clamp or crimper is used, pressure must be applied over the sealing bead of the fitting.


LOCATING BEAD
HOSE

Courtesy of Mitchell Information Services, Inc.

MODULE: HEATING AND AIR CONDITIONING

TESTING AND SERVICING THE COMPRESSOR

Instructions: **Do the following tasks and answer the following questions. Write all responses on this sheet.**

1. Define the following terms:

   Field coil

   Flexplate

   Reed valves

   Superheat switch

   Thermal limiter

2. What material is used to make compressor shaft seals?

3. Describe a special precaution used in seal replacement.

4. Can a pressure-relief valve be installed without discharging the system pressure? Yes___ No___

5. What is an acceptable static gap in a reed plate assembly?

6. What meter reading would indicate that a compressor clutch coil has continuity (no opens)?

7. Perform the following Ohm's law problem: E = 12VDC I = 20 amps.
Solve for ohms:

$$\frac{E}{I/R}$$

8. If a compressor clutch makes a growling noise only when the clutch is engaged, what is most likely the source of the noise?

9. What kind of lubrication should be used when attaching hoses to fittings?

AS1-L1-UV

MODULE: HEATING AND AIR CONDITIONING

TESTING AND SERVICING THE COMPRESSOR

(ANSWER SHEET)

1. A field coil is an electrical winding used to pull the compressor flexplate into engagement.

   On a compressor clutch, the flexplate engages the drive pulley to the compressor drive shaft.

   Reed valves are made of thin metal and provide compressor inlet and outlet valving.

   A superheat switch is a compressor cutout device that throws the thermal fuse when the freon charge within the air conditioning system becomes too low.

   A thermal limiter is a fuse device that opens when it is grounded by the superheat switch.

2. Carbon and ceramic material

3. Always consult the service manual and keep all components clean.

4. No

5. .010

6. Resistance should be low but not zero on Rx1 scale.

7. $\frac{12\text{ volts}}{20\text{ amps}} = .6$ Ohms

8. The internal compressor

9. Refrigerant oil

MODULE: HEATING AND AIR CONDITIONING

PROCEDURES FOR AIR CONDITIONING COMPRESSOR SHAFT SEAL REPLACEMENT

Instructions: Do the following tasks on a separate sheet of paper.

(HINT: Use an appropriate service manual.)

1. Locate an air conditioning compressor that requires shaft seal replacement. Record the make, model, and year of the vehicle in which the compressor is used.

2. Record the make and type of compressor on which the shaft seal will be replaced.

3. Develop a written procedure for replacing the compressor shaft seal. (Make sure the procedure is appropriate for the compressor identified in items 1 and 2 above.)

MODULE: HEATING AND AIR CONDITIONING

PROCEDURES FOR AIR CONDITIONING COMPRESSOR DISASSEMBLY

Instructions: Do the following tasks on a separate sheet of paper.

(HINT: Use an appropriate service manual.)

1. Identify the make and type of compressor to be disassembled. Identify the make, model, and year of the vehicle on which the compressor is used.
2. Develop a written procedure for disassembling the compressor identified in item 1 above.

AS4-L1-UV

MODULE: HEATING AND AIR CONDITIONING

PROCEDURES FOR AIR CONDITIONING COMPRESSOR CLUTCH REPLACEMENT

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Locate an air conditioning compressor that requires clutch replacement. Record the make, model, and year of the vehicle in which the compressor is used.
2. Record the make and type of compressor on which the clutch will be replaced.
3. Develop a written procedure for replacing the compressor clutch. (Make sure the procedure is appropriate for the compressor identified in items 1 and 2 above.)

JS1-L1-UV

MODULE: HEATING AND AIR CONDITIONING

REPLACING THE SHAFT SEAL ON AN AIR CONDITIONING COMPRESSOR

Equipment:

Automotive air conditioning compressor
Seal removal equipment
Service manual
Appropriate wrenches, sockets, and miscellaneous hand tools
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. — — — —
2. Using the procedure outlined below, replace the shaft seal on the compressor. — — — —
    a. Complete AS2-L1-UV.
    b. Discharge the system.
    c. Using the procedure developed in item 1 of AS2-L1-UV, remove the compressor from the vehicle.
    d. Using the procedure developed in item 2 of AS2-L1-UV, replace the shaft seal on an air conditioning compressor.
3. Using the procedure in the Unit V information sheets, leak test the compressor shaft seal. — — — —
4. Using the procedure developed in question 3 of AS2-L1-UV, reinstall the compressor on the vehicle. — — — —
5. Recharge and performance test the air conditioning system. — — — —

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency Gg2. Final evaluation for Gg2 will be made at the end of JS5-L1-UVI.)

MODULE: ELECTRICAL SYSTEMS

REPLACING COMPRESSOR PROTECTION DEVICES

Equipment:

Automotive air conditioning compressor
Appropriate wrenches, sockets, and miscellaneous hand tools
Safety glasses

Procedure: Evaluation 3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __
2. Following the procedure outlined below, replace the pressure-relief valve. __ __ __ __
    a. Discharge the air conditioning system.

       (NOTE: Refer to either JS4-L1-UIV or JS5-L1-UIV for this procedure.)
    b. Remove pressure-relief valve and replace it with a new one.
    c. Check compressor oil level.

       (NOTE: Refer to JS6-L1-UIV for this procedure.)
    d. Evacuate system 20 minutes for each hour it is open.

       (NOTE: Never evacuate the system for more than two hours.)
    e. Recharge to specified level.
3. Following the procedure outlined below, replace the pressure-relief valve. __ __ __ __
    a. Discharge air conditioning system.
    b. Remove switch snap retainer ring.
    c. Pull out switch.
    d. Remove o-ring and replace it with a new one.
    e. Coat switch body with refrigerant oil.
    f. Push in new switch.

g. Replace snap retainer ring.

h. Evacuate the air conditioning system.

i. Recharge and performance test the air conditioning system.

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency Gg2. Final evaluation for Gg2 will be made at the end of JS5-L1-UVI.)

JS3-L1-UV

MODULE: HEATING AND AIR CONDITIONING

REPLACING COMPRESSOR REED PLATES

Equipment:

Automotive air conditioning compressor
Appropriate wrenches, sockets, and miscellaneous hand tools
Special seal removal equipment
Feeler gauge
Service manual
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __

2. Following the procedure outlined below, replace the compressor reed plates. __ __ __ __

   a. Complete AS3-L1-UV.

   b. Following the procedure developed in AS3-L1-UV, disassemble the compressor.

   c. Measure reed plate gap. The gap should not exceed .010 of an inch.

   d. Check for dimpled, bent, or missing reed valves. Replace valves if necessary.

   e. Inspect the plate for burnt compressor oil. Burnt oil will give off a heavy rancid odor and leave brown stains on the plate. Replace the plate if evidence of burnt oil is found.

Average of above evaluations* __ __ __ __

(*This average is a partial evaluation for Competency Gg2. Final evaluation for Gg2 will be made at the end of JS5-L1-UVI.)

JS4-L1-UV

MODULE: HEATING AND AIR CONDITIONING

REPLACING THE COMPRESSOR CLUTCH

Equipment:

Air conditioning compressor
Appropriate wrenches, sockets, and miscellaneous hand tools
Special clutch tools
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Following the procedure outlined below, replace air conditioning compressor clutch. — — — —

    a. Complete AS4-L1-UV.

    b. Discharge the system.

    c. Remove the compressor clutch.

    d. Using the procedure developed in AS4-L1-UV, replace the shaft seal on an air conditioning compressor.

    e. Using the procedure developed in AS4-L1-UV, service the clutch bearing and electromagnetic coil.

    f. Evacuate the air conditioning system.

    g. Recharge and performance test the air conditioning system.

    Average of above evaluations* — — — —

    (*This average is a partial evaluation for Competency Gg2. Final evaluation for Gg2 will be made at the end of JS5-L1-UVI.)

MODULE: HEATING AND AIR CONDITIONING

UNIT V: THE AUTOMOTIVE AIR CONDITIONING COMPRESSOR AND COMPRESSOR CLUTCH

UNIT V TEST

SECTION A. Match the terms below with their appropriate definitions.

____ 1. Compressor cutout device that blows a thermal fuse when the freon charge within the air conditioning system becomes too low.

____ 2. A device that disengages the compressor clutch on the basis of low charge, high charge, or temperature within the air conditioning system.

____ 3. Compressor with pistons arranged along the shaft.

____ 4. Compressor in which pistons are arranged side by side so as to move perpendicular to the crankshaft.

____ 5. The part of a compressor clutch that engages the drive pulley to the compressor drive shaft.

____ 6. Fuse device that opens when it is grounded by the superheat switch.

a. Axial compressor

b. Compressor cutout switch

c. Flexplate

d. In-line compressor

e. Radial compressor

ab. Superheat switch

ac. Thermal limiter

SECTION B. Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.

____ 7. The compressor shaft seal is very vulnerable to freon leaks.

____ 8. Lip seals on compressor shafts have a garland spring that maintains pressure on the seal.

____ 9. Failure of carbon and ceramic seals is most often caused by refrigerant oil collecting on the seal surface.

____ 10. On automotive air conditioning systems, the flexplate is attached to the compressor shaft by several screws.

____ 11. Some compressors can be leak tested before reinstallation of the flexplate.

____ 12. The high-pressure-relief valve on a compressor is very likely to stick and should, therefore, be checked during routine maintenance.

____ 13. The procedure for replacing superheat or low/high pressure cutout switches on an air conditioning system is similar to the procedure for replacing pressure-relief valves.

____ 14. Before reed valves can be inspected or replaced, the compressor must be disassembled.

____ 15. The reed valve gap on a compressor should not exceed .050 of an inch.

____ 16. An infinite ohmmeter reading (on an Rx1 scale) taken from a compressor clutch circuit indicates a possible ground in the circuit.

____ 17. If an ohmmeter reading indicates high resistance in a compressor clutch circuit, there may be an open in the circuit.

____ 18. The clutch bearing rotates when the clutch is disengaged or engaged.

____ 19. If air conditioning compressor noise stops when the compressor clutch is disengaged, the clutch bearing is probably malfunctioning.

____ 20. If air conditioning compressor noise stops when the compressor clutch is engaged, the reed valves are most likely the source of the noise.

____ 21. Neoprene is a material used to make air conditioning hoses.

____ 22. Air conditioning hoses are sized according to either their internal diameter or their length.

____ 23. In addition to connecting air conditioning hoses, o-ring fittings serve as hose pressure valves.

____ 24. During assembly of fittings and air conditioning hoses, the fittings should be free of any refrigerant oil.

____ 25. After o-ring fittings are disconnected, the seals within the fittings should be replaced.

____ 26. Flange o-ring fittings have flat shoulders that are sealed by o-rings or gaskets and compression.

____ 27. The flare fitting is a type of o-ring fitting.

____ 28. A special compound is used to seal the connection between flare fittings.

____ 29. Fittings on air conditioning hoses can sometimes be joined by a clamp or crimper.

____ 30. Air conditioning hoses can sometimes be clamped or crimped together without a fitting.

(NOTE: The student must obtain a minimum score of _____ on the Unit V Test in order to receive an evaluation for Competency Gg2.)

ANSWERS TO UNIT V TEST

1. ab
2. b
3. a
4. d
5. c
6. ac
7. t
8. t
9. f
10. f
11. t
12. f
13. t
14. f
15. f
16. f
17. t
18. t
19. f
20. f
21. t
22. f
23. f
24. f
25. t
26. t
27. f
28. f
29. t
30. t

MODULE: HEATING AND AIR CONDITIONING

UNIT VI: REPAIRING AND REPLACING THE EVAPORATOR, CONDENSER, EXPANSION TUBE, AND RECEIVER-DRIER

UNIT OBJECTIVE

After completing this unit, the student should be able to repair and replace the evaporator, condenser, expansion tube, and receiver-drier. The student will demonstrate mastery of the material by achieving a score of _____ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lesson in this unit, the student should be able to:

Lesson 1. I. Identify terms and definitions associated with the replacement of the evaporator, condenser, expansion tube, and receiver-drier (Competency Gg2, Unit UVI Test).

II. Identify procedures for inspecting, testing, repairing, or replacing high-and low-pressure air conditioning components (Competency Gg2, Unit UVI Test).

III. Demonstrate the ability to:

- a. Inspect, test, and replace the air conditioning condenser (Competency Gg2, JS1-L1-UVI).
- b. Replace a receiver-drier (Competency Gg2, JS2-L1-UVI).
- c. Inspect and test an expansion valve (Competency Gg2, JS3-L1-UVI).
- d. Replace an orifice tube (Competency Gg2, JS4-L1-UVI).
- e. Inspect, test, flush, and replace an evaporator (Competency Gg2, JS5-L1-UVI).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks G004, G006, G009, G010, G011, G012, G022, G024, G026, G027, G028, G029, G030, and G031.

MODULE: HEATING AND AIR CONDITIONING

UNIT VI: REPAIRING AND REPLACING THE EVAPORATOR, CONDENSER, EXPANSION TUBE, AND RECEIVER-DRIER

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

  1. Lesson 1: REPAIRING AND REPLACING AIR CONDITIONING COMPONENTS

    a. Information outline

    b. Assignment sheets

      AS1-L1-UVI: The Condenser, Receiver-Drier, and Evaporator
      AS2-L1-UVI: Procedure for Flushing the Air Conditioning System
      AS3-L1-UVI: Procedure for Removing and Replacing an Evaporator

    c. Job sheets

      JS1-L1-UVI: Inspecting, Testing, and Replacing the Air Conditioning Condenser
      JS2-L1-UVI: Replacing a Receiver-Drier
      JS3-L1-UVI: Inspecting and Testing an Expansion Valve
      JS4-L1-UVI: Replacing an Orifice Tube
      JS5-L1-UVI: Inspecting, Testing, Flushing, and Replacing an Evaporator

E. Unit test

F. Answers to unit test

REFERENCES

Carter Carburetor Division, ACF Industries, Inc. Automotive Air Conditioning Theory and Practice.

Mitchell Information Services, Inc. Heating and Air Conditioning Systems. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1987.

Mitchell International, Inc. Automotive Air Conditioning Basic Service Training Manual. 21st ed. San Diego, CA: Mitchell International Inc., 1988.

Mitchell Manuals, Inc. 1984 Edition Automotive Air Conditioning Basic Service Training Manual. San Diego, CA: Mitchell Manuals, Inc., 1984.

Murray Corporation. Dealer Education Program Temperature Control Clinic Workbook. Cockeysville, MD: Murray Corporation, 1988.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. A portion of JS4-L1-UVI deals with replacing a broken orifice tube. Students should use the procedure under item 2 of this job sheet if the orifice tube is not broken and the procedure under item 3 if the orifice tube is broken.

2. Students should do AS1-L1-UVI before taking the Unit VI test; AS2-L1-UVI and AS3-L1-UVI in conjunction with JS5-L1-UVI.

MODULE: HEATING AND AIR CONDITIONING

UNIT VI: REPAIRING AND REPLACING THE EVAPORATOR, CONDENSER, EXPANSION TUBE, AND RECEIVER-DRIER

LESSON 1:REPAIRING AND REPLACING AIR CONDITIONING COMPONENTS

I. Terms and definitions

- A. Accumulator dehydrator--A liquid freon and oil accumulator.
- B. Aluminum hydroxide--A corrosive chemical that occurs as a result of water in the air conditioning system.
- C. Comb--A tool used to straighten condenser cooling fins.
- D. Condensate--A liquid that forms on the evaporator fins. Condensate occurs when the air that blows across the coils is dehumidified.
- E. Condensate drain--A drain located at the base of the evaporator. This drain removes condensate from the air conditioning system through a valve.
- F. Condenser--A heat exchange device used to transfer heat from inside the air conditioning system to the outside air.
- G. Desiccant--A moisture-absorbing substance used in the receiver-drier or accumulator.
- H. Evaporator--A heat exchange device that takes heat from the passenger compartment and transports it to the condenser.
- I. Flushing--A process by which R-12 is forced through an air conditioning system in order to rid system components of contaminants.
- J. Hydrochloric acid--An acid that forms in the air conditioning system when water mixes with freon.
- K. Receiver-drier--Device found on expansion valve air conditioning systems. The receiver-drier filters moisture from freon and stores excess freon.

II. Inspecting, testing, repairing, or replacing high- and low- pressure air conditioning components

- A. Condenser
    - 1. Procedure for inspecting the condenser
        - a. Inspect the condenser for bugs, dirt, and debris that could cause air blockage.
        - b. Inspect both the condenser and radiator for bent fins. Bent fins can cause air blockage.
        - c. Inspect the condenser for oil deposits resulting from oil and freon leaks. Oil deposits on condenser fins attract dust and dirt, causing air blockage.
        - d. Inspect air flow around after-market oil coolers. Air control panels can accidentally be reshaped during oil cooler installation. The reshaping of air control panels can block air flow around the condenser.

e. Test all hose connections and tubes on the condenser for freon leaks.

2. Procedure for repairing the condenser

   a. Remove the condenser from the air conditioning system, and plug all condenser connections. Wash away all bugs, dirt, and debris from the condenser with soap and water or solvent.

      (**CAUTION:** Condenser tubes are very thin. Be careful not to puncture the tubes while washing them.)

   b. Straighten bent and folded fins with a comb.

   c. The original pattern of air flow around the condenser may be altered during installation of an after-market oil cooler. Restore any alteration in the pattern. Repositioning the oil cooler may also solve air flow problems.

   d. Repair leaks in hose connections.

   e. Repair or replace condenser if leaks are discovered in it.

      (NOTE: Solder any leaks discovered in copper tubes. After soldering, pressure test the air conditioning system to ensure that leaks are repaired.)

      (NOTE: If leaks are discovered in aluminum tubes, replace the unit condenser.)

3. Procedure for replacing the condenser

   a. Discharge air conditioning system according to the proper procedure.

   b. Disconnect fittings.

      (NOTE: Be careful not to twist or break tubing when disconnecting fittings.)

   c. Plug both connections on the air conditioning system.

   d. Remove mounting bolts and any obstructing body parts.

   e. Lift the old condenser from vehicle.

   f. Place the new or repaired condenser into the mounting position.

   g. Install new or repaired condenser by reversing the removal procedure.

   h. Evacuate and recharge the air conditioning system. Add the amount of oil appropriate for condenser replacement.

      (NOTE: Normally 1 ounce of oil should be added to the air conditioning system after replacement of the saturated drier or accumulator.)

4. Procedure for flushing the condenser with a flush gun

   (NOTE: Most manufacturers recommend that, after compressor failure, the entire air conditioning system be flushed and that either the accumulator or receiver-drier be replaced.)

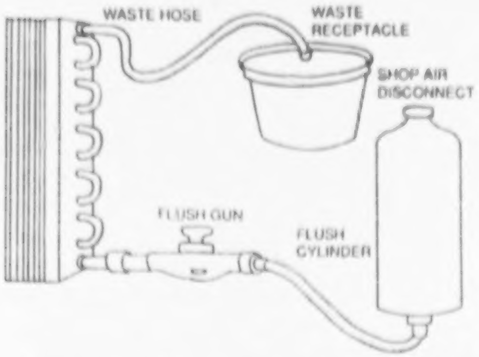
   a. Fill flush (reservoir) cylinder with proper cleaning agent. Close cylinder.

   b. Pressurize flush cylinder with compressed air.

c. Force rubber tip of flush gun against condenser connections. Depress flush gun trigger.

(CAUTION: Protect eyes from flush solvent as it exits the air conditioning system.)

d. Flush air conditioning system until clear flush exits the exhaust fitting.



5. Procedure for flushing the condenser with R-11 gauge set

a. Connect pressurized can of R-11 to the gauge set.

b. Screw special adapters to condenser inlet.

c. Connect gauge set center hose (charge hose) to the special adapter.

d. Open gauge valve.

(CAUTION: Protect eyes from exiting R-11.)

e. Continue flushing air conditioning system until contaminants are no longer exiting the condenser.

B. Receiver-drier

1. Procedure for inspecting the receiver drier or accumulator for saturation of moisture

a. Connect and purge gauge set.

b. Run the engine at a fast idle, and allow the air conditioning system to stabilize. Both the system and the fan should be on the maximum setting during this time.

c. The low-side pressure reading will be normal.

d. The high-side pressure reading will be higher than normal.

e. Look through the sight glass and check for bubbles. Saturated receiver-driers will frequently have moisture bubbles flowing in the system.

f. Check the receiver-drier for an insufficient amount of freon. Insufficient freon reduces the air conditioner's cooling potential.

g. Check expansion valve for blockage resulting from freezing water.

2. Procedure for replacing the saturated receiver-drier or accumulator

    a. Discharge air conditioning system.

    b. Disconnect receiver-drier or accumulator fittings and wiring.

    c. Remove mounting clamp.

    d. Remove old saturated receiver-drier or accumulator.

    e. Flush the entire air conditioning system.

    f. Install new receiver-drier or accumulator by reversing removal procedure.

    g. Evacuate air conditioning system.

    h. Recharge and performance test air conditioning system.

    (NOTE: Add the amount of oil appropriate for the receiver-drier or accumulator being replaced. Normally 1 ounce of oil should be added to the air conditioning system after replacement of the saturated drier or accumulator.)

C. Expansion valve

1. When inspecting the expansion valve, always make sure that it is not stuck open or closed. Also check expansion valve superheat calibration using the procedure outlined below.

2. Procedure for measuring superheat calibration of the expansion valve

    a. Connect pressure gauge set.

    b. Place thermometer in contact with evaporator exhaust pipe.

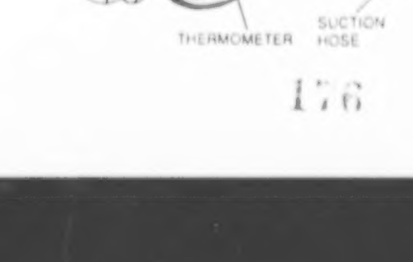
    c. Stabilize system using the appropriate procedure.

    (NOTE: For a more detailed description of the stabilizing procedure, see Unit III of this module.)

    d. Compare low-side pressure and evaporator temperature to superheat chart.

    e. If all other system components are functioning properly, replace the expansion valve. Expansion valve superheat calibration is not field adjustable.

    (NOTE: For a more detailed description of expansion valve replacement procedures, see Unit III of this module.)



3. Procedure for testing expansion valve

    a. Unwrap insulating tape from expansion valve sensing bulb.

    b. Connect a gauge set to the system.

    c. Stabilize the air conditioning system according to the appropriate procedure.

    d. Warm the sensing bulb by hand rubbing it. Observe gauge readings. The gauge reading (which should be low at first) will increase, indicating that the valve is opening.

    e. Place bulb against evaporator inlet pipe. The gauge reading should drop, indicating that the valve is closing.

4. Procedure for installing expansion valve

    a. Discharge system according to the appropriate procedure.

    b. Disconnect fittings according to the appropriate procedure.

       (CAUTION: Double wrench fittings to avoid twisting off the evaporator inlet.)

    c. Install new valve according to sealing practices.

D. Orifice tube

1. When inspecting the orifice tube, always make sure it is not plugged.

   (NOTE: For a more detailed description of orifice tube diagnostic procedures, see Unit III of this module.)

2. Procedure for removing and replacing the orifice tube

    a. Discharge system according to the appropriate procedure.

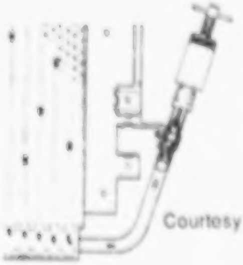
    b. Disconnect evaporator inlet fitting.

    c. Using the appropriate tool, remove the orifice tube.

d. Add the appropriate amount of replacement oil to the orifice tube.

e. Replace orifice tube by reversing disassembly procedures.

f. Evacuate and then recharge the air conditioning system.



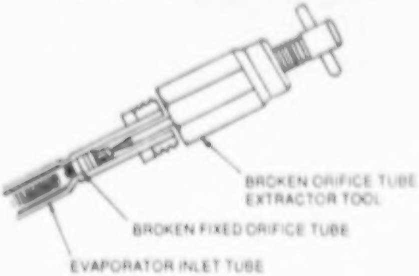
Courtesy of Mitchell Information Services, Inc

3. Procedure for removing a broken orifice tube

a. Using a special tool, screw extractor into the body of the broken orifice tube.

(**CAUTION:** Screwing the extractor too deeply into the orifice tube body will over expand the tube and prevent its removal. Be sure to screw in the extractor only deep enough to establish a secure grip on the tube.)

b. Use a jamb nut to pull the broken tube.

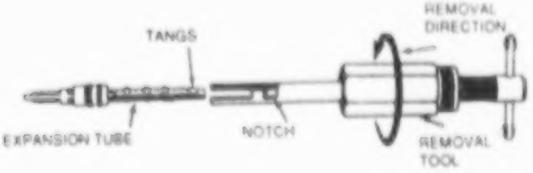

BROKEN ORIFICE TUBE EXTRACTOR TOOL
BROKEN FIXED ORIFICE TUBE
EVAPORATOR INLET TUBE

E. Evaporator

1. Procedure for leak testing the evaporator

a. Pass the sensing hose of either a propane or electronic leak detection equipment beneath the evaporator. Also put the hose into the outlet ducts.

b. Pass the hose beneath inlet and outlet tubes.

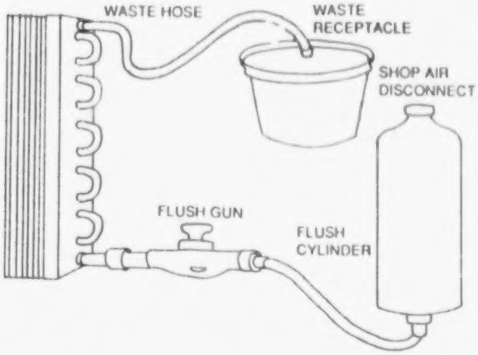

TANGS
REMOVAL DIRECTION
EXPANSION TUBE
NOTCH
REMOVAL TOOL

Courtesy of Mitchell Information Services, Inc

2. Procedure for flushing the evaporator

a. Using setup procedure for flushing system.

b. Flush system until charge is empty or until clear solvent comes out of the hose.


WASTE HOSE
WASTE RECEPTACLE
SHOP AIR DISCONNECT
FLUSH GUN
FLUSH CYLINDER

3. Procedure for removing and replacing the evaporator

   a. Obtain from an appropriate service manual specific steps of procedure for removing and replacing the evaporator.

   b. Double wrench all fittings during disassembly and reassembly.

   (NOTE: Normally 3 ounces of oil should be added to the air conditioning system after replacement of the evaporator.)

4. Procedure for inspecting and repairing evaporator drain hose (condensate drain)

   a. Probe drain hose with a wire to determine if hose is clogged with dust.

   b. Inspect drain hose for mold, flash, and damaged drain tube ends.

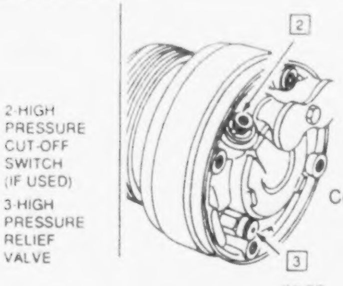
F. Relief valve

1. Procedure for replacing relief valve

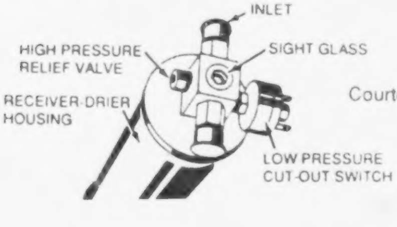
   a. Discharge system according to the appropriate procedure.

   b. Unscrew relief valve.

   c. Using a thread sealer, replace relief valve. Tighten valve to manufacturer's specifications.


2
2-HIGH PRESSURE CUT-OFF SWITCH (IF USED)
3-HIGH PRESSURE RELIEF VALVE
3

Courtesy of General Motors Corporation


INLET
HIGH PRESSURE RELIEF VALVE
SIGHT GLASS
RECEIVER-DRIER HOUSING
LOW PRESSURE CUT-OUT SWITCH

Courtesy of Mitchell Information Services, Inc

MODULE: HEATING AND AIR CONDITIONING

THE CONDENSER, RECEIVER-DRIER, AND EVAPORATOR

Instructions: **Do the following tasks and answer the following questions. Write all responses on this sheet.**

1. Define the terms listed below:

Aluminum hydroxide

Comb

Condensate

Desiccant

Hydrochloric acid

Receiver-drier

2. Name four types of condenser air-flow blockage.

3. Name two cleaning agents that can be used to flush air conditioning components.

4. When replacing a receiver-drier assembly, how should a technician determine the amount of recharge oil required?

5. What precaution must be taken during expansion valve replacement?

6. Warming an expansion valve sensing bulb will have what effect on evaporator pressure?

7. How should a broken orifice tube be removed?

8. Evaporator condensate drains must be checked for what problem?

9. What must be done to the pressure in an automotive air conditioning system before replacing a high-pressure relief valve?

MODULE: HEATING AND AIR CONDITIONING

THE CONDENSER, RECEIVER-DRIER, AND EVAPORATOR

(ANSWER SHEET)

1. Aluminum hydroxide is a corrosive chemical which occurs as a result of water in the air conditioning system.

   A comb is a tool used to straighten condenser cooling fins.

   Condensate is a liquid that forms on the evaporator fins.

   Desiccant is a moisture-absorbing substance used in a receiver-drier or accumulator.

   Hydrochloric acid is a substance that forms in the air conditioning system when water mixes with freon.

   A receiver-drier is a device that filters moisture from freon and stores excess freon.

2. Bugs, dirt (and other debris), bent fins, oil contamination, after-market oil coolers
3. R-12 or air conditioning flush solution
4. The technician should refer to the oil-change chart.
5. The technician should use two wrenches on all fittings.
6. The pressure will be raised.
7. A broken orifice tube should be removed with a special screw extractor.
8. Clogging
9. Discharged

AS2-L1-UVI

MODULE: HEATING AND AIR CONDITIONING

PROCEDURE FOR FLUSHING THE AIR CONDITIONING SYSTEM

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual or the instructions accompanying the flush kit.)

1. Develop a written procedure for flushing the air conditioning system to be serviced. Include all safety precautions in the procedure.

MODULE: HEATING AND AIR CONDITIONING

PROCEDURE FOR REMOVING AND REPLACING AN EVAPORATOR

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for removing and replacing the evaporator in the vehicle's air conditioning system.

JS1-L1-UVI

MODULE: HEATING AND AIR CONDITIONING

INSPECTING, TESTING, AND REPLACING THE AIR CONDITIONING CONDENSER

Equipment:

Selected vehicle
Sockets, wrenches, etc.
Condenser comb
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. — — — —

2. Using the procedure outlined below, check the air flow around the condenser. — — — —

    a. Check for bugs, dirt, debris on the radiator and the condenser surface.

    b. Check for bent condenser fins.

       (NOTE: Straighten bent fins with a condenser comb.)

    c. Check for blockage caused by dirt accumulated over oil stains.

    d. If stains are found, locate the source of the leak causing the stains and make repairs. Record the source of the leak and the procedure used to repair it.

    e. Check for reductions in air flow around the condenser and radiator. Air flow may be reduced by after-market oil coolers.

3. Test the condenser for leaks. Record results. — — — —

(NOTE: When flushing the system use either procedure 2 or 3.)

4. Following the procedure outlined below, flush the condenser with a flush gun. — — — —

   a. Using a refillable reservoir, fill flush gun reservoir with cleaning agent.

   b. Pressurize flush gun reservoir with compressed air. Bring reservoir to the maximum pressure allowed by manufacturer's specification.

   c. Force rubber tip of flush gun into condenser inlet and depress flush gun trigger.

   d. Continue flushing until fluid exiting the condenser is clear.

5. Following the procedure outlined below, flush the condenser with R-11 or flushing solution. — — — —

   a. Connect R-11 or flushing solution container to gauge set.

   b. Attach gauge set center hose to special adaptor.

   c. Screw special adaptor to condenser inlet and open gauge valve.

   d. Continue flushing until fluid exiting the condenser is clear.

6. Following the procedure outlined below, replace the condenser. — — — —

   a. Discharge the air conditioning system.

   b. Disconnect fitting double wrench to avoid twisting connections.

   c. Plug system connections.

   d. Remove mounting bolts and any other obstructing body parts.

   e. Remove condenser.

   f. Replace the old condenser with a new one.

   g. Put new o-rings on condenser connections.

   (NOTE: Add the appropriate amount of oil for condenser replacement, normally 1 ounce.)

h. Evacuate and recharge air conditioning system. Refer to JS7-L1-UIV for the procedure.

i. Performance test air conditioning system.
Refer to JS2-L1-UIV for procedure.

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency Gg2. Final evaluation for Gg2 will be made at the end of JS5-L1-UVI.)

JS2-L1-UVI

MODULE: HEATING AND AIR CONDITIONING

REPLACING A RECEIVER-DRIER

Equipment:

Appropriate sockets
Safety glasses

Procedure: Evaluation 3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Following the procedure outlined below, replace the receiver-drier. ___ ___ ___ ___

   a. Discharge the air conditioning system. Refer to JS4-L1-UIV or JS5-L1-UIV.

   b. Disconnect the receiver-drier or accumulator fittings and wiring.

   c. Remove receiver-drier mounting screws and then remove receiver-drier.

   d. Reversing the above removal procedure, install new receiver-drier with new o-rings.

      (NOTE: Add the amount of oil appropriate for condenser replacement, normally 1 ounce.)

   e. Evacuate the air conditioning system.
      Refer to JS7-L1-UIV.

   f. Recharge the air conditioning system.

   g. Performance test the air conditioning system. Refer to JS2-L1-UIV.

   Average of above evaluations* ___ ___ ___ ___

   (*This average is a partial evaluation for Competency Gg2. Final evaluation for Gg2 will be made at the end of JS5-L1-UVI.)

MODULE: HEATING AND AIR CONDITIONING

INSPECTING AND TESTING AN EXPANSION VALVE

Equipment:

Thermometer
Selected vehicle
Standard air conditioning gauge set
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. _ _ _ _

2. Following the procedure outlined below, calibrate the expansion valve. _ _ _ _

   a. Connect pressure gauge set.

   b. Place thermometer in contact with evaporator outlet.

   c. Stabilize system.

   d. Compare low-side pressure and evaporator exhaust temperature to superheat chart. Replace expansion valve if specifications are not met. Record observations.

3. Following the procedure outlined below, perform an operational test on the expansion valve. _ _ _ _

   a. Connect a gauge set and purge.

   b. Unwrap insulating tape from expansion valve sensing bulb.

   c. Run the engine and air conditioner on maximum until the system stabilizes.

   d. Place hands on both sides of the expansion valve. The inlet should be warm and the outlet cool to the touch. Usually a 15- to 20-degree difference is normal.

   e. Place a rag saturated with hot water on the expansion valve or sensor bulb.

f. Monitor the air conditioning system with the gauge set while holding the rag on the valve. The high-side pressure should drop and the low-side pressure should rise, indicating that the valve is opening.

g. To reverse the operation of the expansion valve, spray the expansion valve or sensor bulb with a small quantity of freon.

h. Monitor the air conditioning system with the gauge set. The high-side pressure should rise and the low-side pressure should drop, indicating that the valve is closed.

4. Procedure for measuring superheat calibration of the expansion valve

a. Connect pressure gauge set.

b. Place thermometer in contact with evaporator exhaust pipe.

c. Stabilize system using the appropriate procedure.

(NOTE: For a more detailed description of the stabilizing procedure, see Unit IV of this module.)

d. Compare low-side pressure and evaporator temperature to superheat chart.

e. If all other system components are functioning properly, replace the expansion valve. Superheat calibration on the expansion valve is not field adjustable.

5. If the proper gauge readings are not obtained during the operational test of the expansion valve, replace the valve. Follow the procedure outlined below. — — — —

   a. Discharge system.

   b. Disconnect fittings.

   c. Install new valve.

   d. Wrap new valve with insulating tape.

   e. Place bulb in contact with evaporator.

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency Gg2. Final evaluation for Gg2 will be made at the end of JS5-L1-UVI.)

JS4-L1-UVI

MODULE: HEATING AND AIR CONDITIONING

REPLACING AN ORIFICE TUBE

Equipment:

Orifice tube removal tool
Orifice tube extractor
Wrenches
Service manual
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Following the procedure outlined below, remove the orifice tube. ___ ___ ___ ___

   (NOTE: Use the procedure under item 2 if the orifice tube is not broken. If tube is broken, use the procedure under item 3.)

   a. Discharge system.

   b. Disconnect orifice tube connection.

   c. Using appropriate removal tool, remove orifice tube.

3. Following the procedure outlined below, replace a broken orifice tube. ___ ___ ___ ___

   a. Discharge the system.

   b. Screw special extractor into the broken tube.

   c. Pull tube with tool jam nut.

      (**CAUTION:** Screw extractor only tight enough to grip the tube. Over tightening will expand the tube, thus making its removal more difficult.)

4. Following the procedure outlined below, install the orifice tube. _ _ _ _

   a. Coat the new orifice tube with refrigerant oil and install the orifice tube in the line.

   (NOTE: Push the orifice tube tightly against its seat in the line.)

   b. Add the specified amount of refrigerant oil to the system.

   c. Coat the o-ring in the fitting with oil and hand screw it together.

   d. Using two wrenches, tighten the fitting.

   e. Evacuate the system. Refer to JS7-L1-UIV for this procedure.

   f. Recharge the air conditioning system. Refer to JS7-L1-UIV for this procedure.

   g. Performance test the air conditioning system. Refer to JS2-L1-UIV for this procedure.

   Average of above evaluations* _ _ _ _

   (*This average is a partial evaluation for Competency Gg2. Final evaluation for Gg2 will be made at the end of JS5-L1-UVI.)

MODULE: HEATING AND AIR CONDITIONING

INSPECTING, TESTING, FLUSHING, AND REPLACING AN EVAPORATOR

Equipment:

Leak detection equipment
Flushing tool
Service manual
Wrenches, sockets, etc.
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Following the procedure outlined below, check the evaporator for leaks. ___ ___ ___ ___

    a. Run air conditioning system on maximum setting for five minutes.

    b. Turn system off.

    c. Using freon leak tester, check the lower outlets for freon leakage. Record observations.

    d. Pass the freon leak tester under inlet and outlet fittings. Record observations.

    e. Repair or replace as needed.

3. Following the procedure outlined below, inspect condensate drain hose. _ _ _ _

    a. Probe outlet with a wire to detect clogging due to dust or road debris. Record observations.

    b. Make sure molded slot has proper flash. Also inspect slot for damage. Record observations.

    c. Make any needed repairs on the condensate drain hose. Record any repairs made.

4. Following the procedure outlined below, flush the evaporator. _ _ _ _

    a. Discharge the system.

    b. Disconnect the evaporator.

    c. Complete AS2-L1-UVI.

    d. Using the procedure developed in AS2-L1-UVI, flush evaporator.

    (**CAUTION:** Flushing apparatus is under very high pressure. Severe injury may result if apparatus is not handled properly).

    (NOTE: Add the amount of oil appropriate for evaporator replacement.)

    e. Reconnect inlet and outlet. Install new o-rings.

    f. Evacuate the air conditioning system.

    g. Recharge air conditioning system.

5. Following the procedure outlined below, remove and replace an evaporator. _ _ _ _

   a. Complete AS3-L1-UVI.

   b. Using the procedure developed in AS3-L1-UVI, replace the evaporator.

   Average of above evaluations* _ _ _ _

   (*This average is a partial evaluation for Competency Gg2. Final evaluation for Gg2 will be made at the end of this job sheet.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency Gg2 by averaging the evaluations of JS6-L1-UIV, JS1-L1-UV, JS2-L1-UV, JS3-L1-UV, JS4-L1-UV, JS1-L1-UVI, JS2-L1-UVI, JS3-L1-UVI, JS4-L1-UVI, and JS5-L1-UVI. Use the spaces provided below.

	Evaluation			
	3	2	1	N
JS6-L1-UIV	___	___	___	___
JS1-L1-UV	___	___	___	___
JS2-L1-UV	___	___	___	___
JS3-L1-UV	___	___	___	___
JS4-L1-UV	___	___	___	___
JS1-L1-UVI	___	___	___	___
JS2-L1-UVI	___	___	___	___
JS3-L1-UVI	___	___	___	___
JS4-L1-UVI	___	___	___	___
JS5-L1-UVI	___	___	___	___
Final evaluation for Competency Gg2	___	___	___	___

MODULE: HEATING AND AIR CONDITIONING

UNIT VI: REPAIRING AND REPLACING THE EVAPORATOR, CONDENSER, EXPANSION TUBE, AND RECEIVER-DRIER

UNIT VI TEST

SECTION A: **Match the terms below with their appropriate definitions.**

____ 1. A moisture-absorbing substance used in the receiver drier or accumulator.

____ 2. An acid which forms in the air conditioning system when water mixes with freon.

____ 3. A corrosive chemical which occurs as a result of water in the air conditioning system.

____ 4. A heat exchange device which takes heat from the passenger compartment and transports it to the condenser.

____ 5. A heat exchange device used to transfer heat from inside of the air conditioning system to the outside air.

____ 6. A tool used to straighten condenser cooling fins.

a. Aluminum hydroxide

b. Comb

c. Condensate

d. Condenser

e. Desiccant

ab. Evaporator

ac. Hydrochloric acid

SECTION B: **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 7. After-market oil coolers can sometimes interfere with the flow of air around condensers.

____ 8. Condensers should be coated with a light oil as a part of regular maintenance.

____ 9. After a condenser is removed, it can be washed with soap and water.

____ 10. Condenser tubes are usually a grouping of 1/4" steel or lead pipes.

____ 11. Normally 5 ounces of oil should be added to the air conditioning system after replacement of the saturated drier or accumulator.

____ 12. Frozen water can sometimes block the receiver-drier expansion valve.

____ 13. The air conditioning system should be discharged before removing or replacing air conditioning components such as the receiver-drier or condenser.

____ 14. Superheat calibration on the expansion valve is not field adjustable.

____ 15. A broken orifice tube can be removed with a pair of pliers.

____ 16. Only electronic leak detection equipment should be used to test an evaporator for leaks.

____ 17. The evaporator drain hose (condensate drain) should be probed with a wire to detect clogs.

____ 18. All fittings should be double wrenched during disassembly and reassembly of the evaporator.

____ 19. Usually no oil will need to be added to the air conditioning system after evaporator replacement.

(NOTE: The student must obtain a minimum score of ____ on the Unit VI test in order to receive an evaluation for Competency Gg2.)

ANSWERS TO UNIT VI TEST

1. e
2. ac
3. a
4. ab
5. d
6. b
7. t
8. f
9. t
10. f
11. f
12. t
13. t
14. t
15. f
16. f
17. t
18. t
19. f

MODULE: HEATING AND AIR CONDITIONING

UNIT VII: THE AUTOMOTIVE HEATING SYSTEM AND ENGINE COOLING SYSTEM

UNIT OBJECTIVE

After completing this unit, the student should be able to identify the principles by which a vehicle's heating system operates and diagnose and repair the system. The student will demonstrate mastery of the material by achieving a score of _____ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify terms and definitions associated with heating system operation (Competency Hh1, Unit VII Test).

II. Identify the principles by which the heater core operates (Competency Hh1, Unit VII Test).

III. Identify systems that control the heater core (Competency Hh1, Unit VII Test).

IV. Identify the principles by which the engine cooling system operates (Competency Hh1, Unit VII Test).

Lesson 2.

I. Identify procedures for diagnosing heating system problems (Competency Hh1, Unit VII Test).

II. Identify procedures for diagnosing leaks within the heating system (Competency Hh1, Unit VII Test).

III. Demonstrate the ability to:

   a. Diagnose the vehicle's heating system (Competency Hh1, JS1-L2-UVII).

   b. Diagnose coolant leaks in the vehicle's heating system (Competency Hh1, JS2-L2-UVII).

   c. Diagnose thermostat malfunction in the vehicle's heating system (Competency Hh1, JS3-L2-UVII).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks G036-G038.

MODULE: HEATING AND AIR CONDITIONING

UNIT VII: THE AUTOMOTIVE HEATING SYSTEM AND ENGINE COOLING SYSTEM

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

  1. Lesson 1: OPERATION OF THE HEATING SYSTEM

    a. Information outline

  2. Lesson 2: DIAGNOSING AND REPAIRING AUTOMOTIVE HEATING SYSTEM PROBLEMS

    a. Information outline

    b. Assignment sheets

      AS1-L2-UVII: Operation of an Automotive Heating System

    c. Job sheets

      JS1-L2-UVII: Diagnosing an Automotive Heating System
      JS2-L2-UVII: Diagnosing Coolant Leaks in an Automotive Heating System
      JS3-L2-UVII: Diagnosing Thermostat Malfunction in an Automotive Heating System

E. Unit test

F. Answers to unit test

REFERENCES

Carter Carburetor Division, ACF Industries, Inc. Automotive Air Conditioning Theory and Practice.

Mitchell Information Services, Inc. Heating and Air Conditioning Systems. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1987.

Mitchell International, Inc. Automotive Air Conditioning Basic Service Training Manual. 21st ed. San Diego, CA: Mitchell International Inc., 1988.

Mitchell Manuals, Inc. 1984 Edition Automotive Air Conditioning Basic Service Training Manual. San Diego, CA: Mitchell Manuals, Inc., 1984.

Murray Corporation. Dealer Education Program Temperature Control Clinic Workbook. Cockeysville, MD: Murray Corporation, 1988.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Students should do AS1-L2-UVII before taking the Unit VII Test.

MODULE: HEATING AND AIR CONDITIONING

UNIT VII: THE AUTOMOTIVE HEATING SYSTEM AND ENGINE COOLING SYSTEM

LESSON 1: OPERATION OF THE HEATING SYSTEM

I. Terms and definitions

A. Blend door--An air-flow control door that allows some air to bypass the heater core.

B. Control doors--Moveable doors that control the direction or rate of air flow through the heater and air conditioning plenum.

C. Dash control panel--Heating and air conditioning controls mounted on an instrument panel, located in the vehicle's dashboard. The dash control panel allows the driver to operate the vehicle's heating and air conditioning system.

D. Defrost--A blend door position that directs air onto the vehicle windows in order to defog or defrost them.

E. Heater core--A device that transfers heat from the engine coolant to the surrounding air, which then flows into the vehicle's passenger compartment.

F. Plenum chamber--A housing that contains the heater core, evaporator, blend and control doors, and blower motor. In the plenum chamber, heat from the heater core is exchanged with the outside air. This outside air is then directed to the passenger compartment.

G. Radiator--A device that transfers heat from the engine coolant to the surrounding air.

H. Ram air--Air that enters the plenum chamber or flows across the radiator as the vehicle moves down the road.

I. Registers--Outlets that allow warm or cool air to circulate from the plenum chamber to a variety of areas in the passenger compartment.

J. Thermostat--A coolant-control valve that allows or prevents coolant flow based upon coolant temperature.

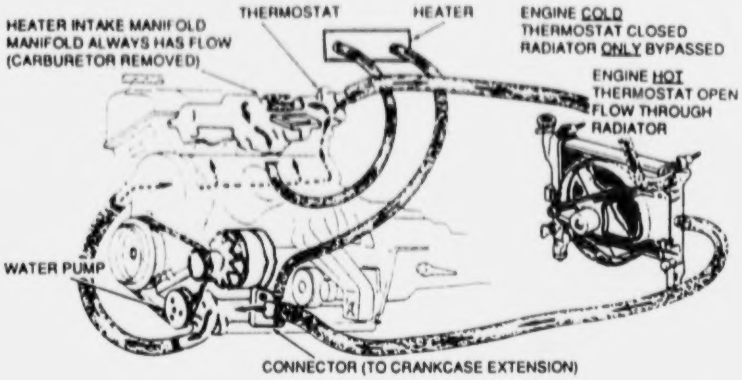
K. Vacuum motor--A closed chamber with a rubber diaphragm in the middle. When a vacuum is created at one side of the chamber, the diaphragm is pulled in that direction, thus creating linear mechanical motion.

L. Water pump--An engine-mounted pump that forces coolant to circulate throughout the engine and heater system.

II. The heater core

A. As engine coolant circulates through the coolant tubes of the heater core, a blower forces air across the core fins. As a result, heat from the coolant within the fins is transferred to this air, which then circulates to the vehicle's passenger compartment.

B. Coolant always circulates from the upper side of the engine, which is hotter, to the lower side (toward the radiator), which is cooler. When coolant is circulating within the heater core or radiator, the outlet port of the core should be cooler than the inlet port. The outlet port, however, should never be cold.


HEATER INTAKE MANIFOLD
MANIFOLD ALWAYS HAS FLOW
(CARBURETOR REMOVED)
THERMOSTAT
HEATER
ENGINE COLD
THERMOSTAT CLOSED
RADIATOR ONLY BYPASSED
ENGINE HOT
THERMOSTAT OPEN
FLOW THROUGH
RADIATOR
WATER PUMP
CONNECTOR (TO CRANKCASE EXTENSION)

Courtesy of Chrysler Motors Corporation

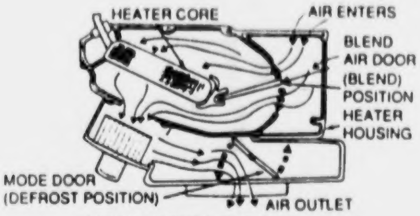
III. The temperature of the air entering the passenger compartment across the heater core can be controlled by one of the following systems: the blend-air system; the blend-air system with modulating water valve; or the stacked-core system.

A. Blend-air system

(NOTE: In the blend-air system described below, the flow of coolant to the heater core is not controlled or restricted.)

1. In a typical blend-air system, air enters the plenum through the plenum chamber inlet. In the plenum chamber, a blend door (controlled from the dash) directs some of the air through the heater core fins, where the air is heated. The remaining air completely bypasses the core and remains cool. Finally the warm and cool air blend together and enter the passenger compartment.

2. In vehicles with blend-air systems, the temperature of the passenger compartment is determined by the amount of air that passes through the heater core fins. When the driver sets the dash heater control on maximum cool, the blend door causes all incoming air to bypass the core. When the control is set for maximum heat, the blend door causes all air to flow across the heater core fins. When the control is set between maximum heat and maximum cool, the blend door allows only some air to pass through the core fins.


HEATER CORE
AIR ENTERS
BLEND
AIR DOOR
(BLEND)
POSITION
HEATER
HOUSING
MODE DOOR
(DEFROST POSITION)
AIR OUTLET

TYPICAL BLEND AIR HEATER SYSTEM

Courtesy of Chrysler Motors Corporation

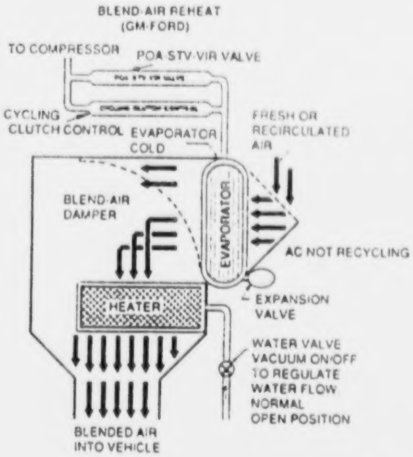
3. Sometimes the temperature of the air that bypasses the heater core is not significantly lower than the temperature of the air that flows across the heater core fins. If this is the case, the air conditioner will cycle to provide air that is sufficiently cool. If the heater control is set at its lowest level, all air entering the passenger compartment may be coming directly from the air conditioner. Items 4 through 6 below describe how the blend-air system operates with and without the air conditioner.

4. Blend-air system operation (with air conditioner off)

    a. Air conditioner compressor is off.

    b. All air flows across the heater core (none is allowed to bypass core).

    c. Ram air or blower speed determines air flow rate.


BLEND-AIR REHEAT (GM-FORD)
TO COMPRESSOR
POA-STV-VIR VALVE
CYCLING CLUTCH CONTROL
EVAPORATOR COLD
FRESH OR RECIRCULATED AIR
BLEND-AIR DAMPER
EVAPORATOR
AC NOT RECYCLING
HEATER
EXPANSION VALVE
WATER VALVE VACUUM ON/OFF TO REGULATE WATER FLOW NORMAL OPEN POSITION
BLENDED AIR INTO VEHICLE

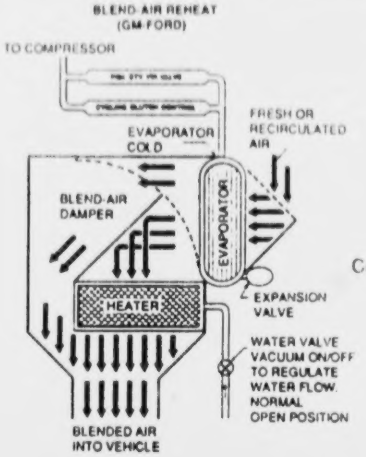
Courtesy of Murray Corporation

5. Blend-air system operation (with both heat and air conditioner on)

    a. Depending on the temperature control setting, the air conditioner may or may not be cycled on.

    b. Some air flows across the heater core fins while some flows around the core. The air that flows around the core later blends with the heated air.

    c. Temperature of outlet air is determined by the ratio of hot air blended to cold air and the cycle of the air conditioning compressor.


BLEND-AIR REHEAT (GM-FORD)
TO COMPRESSOR
EVAPORATOR COLD
FRESH OR RECIRCULATED AIR
BLEND-AIR DAMPER
EVAPORATOR
HEATER
EXPANSION VALVE
WATER VALVE VACUUM ON/OFF TO REGULATE WATER FLOW. NORMAL OPEN POSITION
BLENDED AIR INTO VEHICLE

Courtesy of Murray Corporation

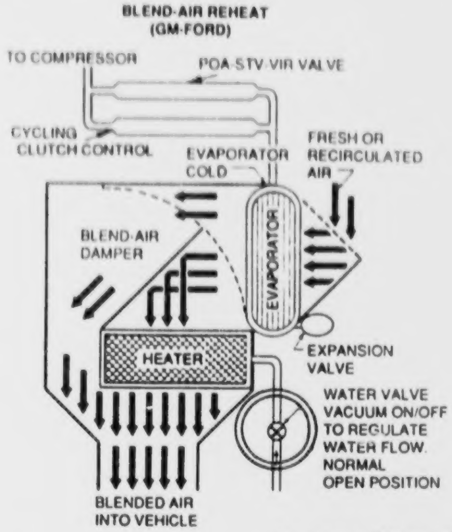
6. Blend-air system operation (with air conditioning on and heater off)

   1. Air conditioning compressor is on.

   2. Blend door is closed; therefore, all air bypasses the heater core.

B. Blend-air system with modulating water valve

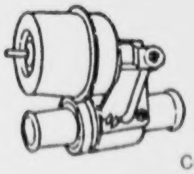
   1. Some blend-air systems use a modulating water valve or an adjustable water valve to control passenger compartment temperatures. In all other respects, air blend systems using these valves function exactly like those without them.


BLEND-AIR REHEAT
(GM-FORD)
TO COMPRESSOR
POA-STV-VIR VALVE
CYCLING CLUTCH CONTROL
EVAPORATOR COLD
FRESH OR RECIRCULATED AIR
BLEND-AIR DAMPER
EVAPORATOR
HEATER
EXPANSION VALVE
WATER VALVE VACUUM ON/OFF TO REGULATE WATER FLOW. NORMAL OPEN POSITION
BLENDED AIR INTO VEHICLE

Courtesy of Murray Corporation

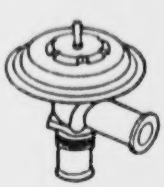
   a. The modulating valve controls the amount of coolant flowing through the heater core. The modulating valve is controlled by either a cable or a vacuum signal.

   b. Most water valves do not meter the flow of coolant through the heater core; usually the valves simply turn coolant flow on and off.



Courtesy of Murray Corporation

   c. Vacuum controlled heater valves control coolant flow to the heater core. The valves close when a vacuum signal is sent to the valve's vacuum port.



Courtesy of Murray Corporation

d. If either a type I or a type II vacuum controlled heater valve fail, the valve will usually remain in the open position, thus allowing coolant to flow to the heater core.

(**CAUTION:** If a diaphragm on a type II heater valve ruptures, coolant may be sucked into vacuum lines and damage either the temperature control devices or the automatic temperature control unit and its sensors.)

2. Sometimes the temperature of the air that bypasses the heater core is not significantly lower than the air that passes through the heater core fins. If this is the case, the air conditioner will automatically cycle to provide air that is sufficiently cool. If the heater control is set at its lowest level, all air entering the passenger compartment may be coming directly from the air conditioner. Items 3 through 5 below describe how the blend-air system operates with and without the air conditioner.

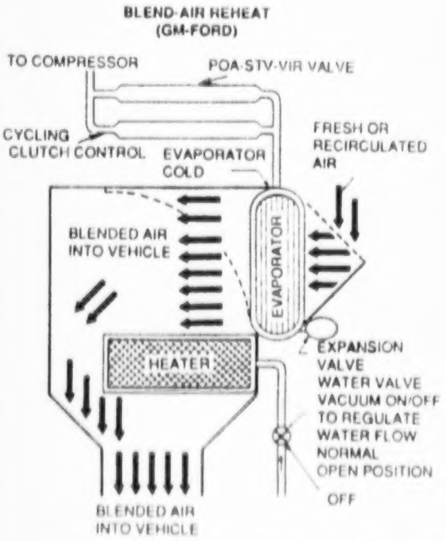
3. Operation of blend-air system with modulating water valve (with air conditioner off)

   a. Air conditioner compressor is off.

   b. All air flows across the heater core (none is allowed to bypass core).

   c. Water or modulating valve is wide open and, therefore, allows the heater core to remain hot.

   d. Ram air or blower speed determines air flow rate and forces air across the heater core.


BLEND-AIR REHEAT
(GM-FORD)
TO COMPRESSOR
POA-STV-VIR VALVE
CYCLING CLUTCH CONTROL
EVAPORATOR COLD
FRESH OR RECIRCULATED AIR
BLENDED AIR INTO VEHICLE
EVAPORATOR
HEATER
EXPANSION VALVE
WATER VALVE VACUUM ON/OFF TO REGULATE WATER FLOW NORMAL OPEN POSITION
OFF
BLENDED AIR INTO VEHICLE

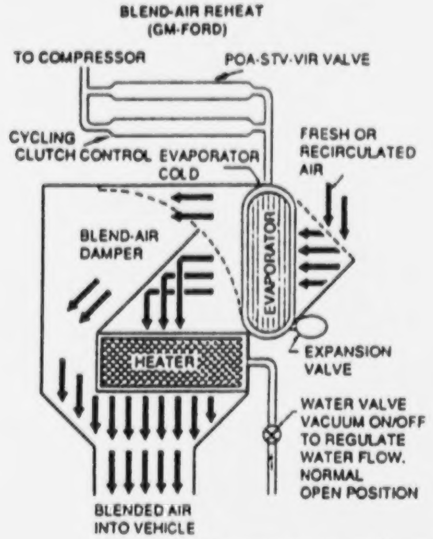
Courtesy of Murray Corporation

4. Operation of blend-air system with modulating water valve (with air conditioner and heat both on)

   a. Depending on the temperature control setting, the air conditioner may or may not be cycling.

b. Some air flows through the heater while some flows around the core. The air that flows around the core later blends with the heated air.

c. Temperature of outlet air is determined by the ratio of hot air blended with cold air and the cycle of the air conditioning compressor.


BLEND-AIR REHEAT
(GM-FORD)
TO COMPRESSOR
POA-STV-VIR VALVE
CYCLING CLUTCH CONTROL
EVAPORATOR COLD
FRESH OR RECIRCULATED AIR
BLEND-AIR DAMPER
EVAPORATOR
EXPANSION VALVE
HEATER
WATER VALVE VACUUM ON/OFF TO REGULATE WATER FLOW. NORMAL OPEN POSITION
BLENDED AIR INTO VEHICLE

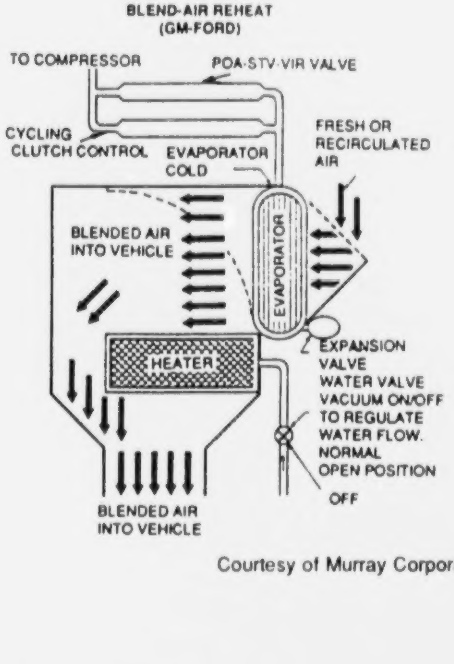
Courtesy of Murray Corporation

5. Operation of blend-air system with modulating water valve (air conditioner on and heater off)

   a. Air conditioning compressor is on.

   b. Blend door is closed; therefore, all air bypasses the heater core.

   c. The valve in the heater core is off.

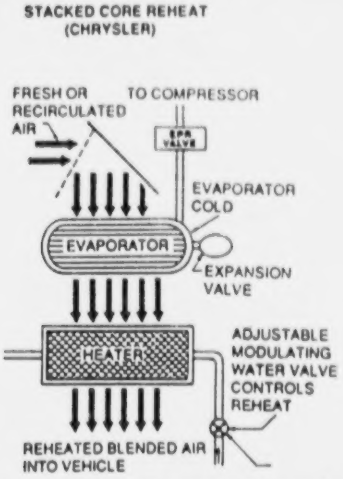

BLEND-AIR REHEAT
(GM-FORD)
TO COMPRESSOR
POA-STV-VIR VALVE
CYCLING CLUTCH CONTROL
EVAPORATOR COLD
FRESH OR RECIRCULATED AIR
BLENDED AIR INTO VEHICLE
EVAPORATOR
EXPANSION VALVE
HEATER
WATER VALVE VACUUM ON/OFF TO REGULATE WATER FLOW. NORMAL OPEN POSITION
OFF
BLENDED AIR INTO VEHICLE

Courtesy of Murray Corporation

C. Stacked-core system

(NOTE: Manufacturers are using stacked-core systems less frequently on their late-model cars.)

1. In the stacked-core system, all air entering the passenger compartment flows across both the evaporator and heater core. A water valve (which is controlled from the dash by either a cable or a vacuum) in one of the hoses connected to the heater core regulates the amount of coolant flowing through the heater. The air moving around the core (and into the passenger compartment) becomes warmer or cooler according to the variations in coolant flow.


STACKED CORE REHEAT
(CHRYSLER)
FRESH OR RECIRCULATED AIR
TO COMPRESSOR
EPR VALVE
EVAPORATOR COLD
EVAPORATOR
EXPANSION VALVE
HEATER
ADJUSTABLE MODULATING WATER VALVE CONTROLS REHEAT
REHEATED BLENDED AIR INTO VEHICLE

Courtesy of Murray Corporation

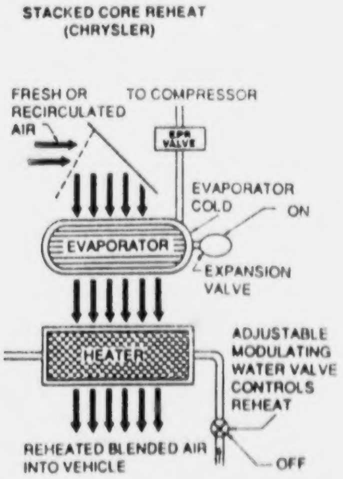
2. Operation of the stacked-core system (air conditioner off)

   a. Air conditioning compressor is not cycling.

   b. Fresh or recirculated air flows through the dormant evaporator and onto the heater core.

   c. Temperature of heater core is modulated by the heater control valve.

   d. Air flow rate is determined by ram air or blower speed.


STACKED CORE REHEAT
(CHRYSLER)
FRESH OR RECIRCULATED AIR
TO COMPRESSOR
EPR VALVE
EVAPORATOR COLD
ON
EVAPORATOR
EXPANSION VALVE
HEATER
ADJUSTABLE MODULATING WATER VALVE CONTROLS REHEAT
REHEATED BLENDED AIR INTO VEHICLE
OFF

Courtesy of Murray Corporation

3. Operation of the stacked-core system (air conditioner on and heater off)

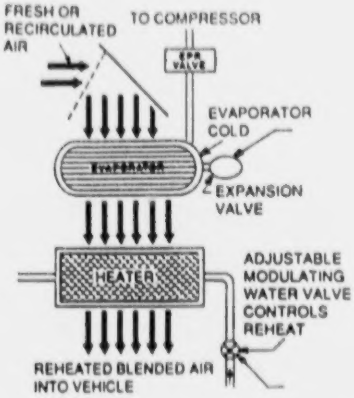
   a. Air conditioner compressor is cycling.

   b. Fresh or recirculated air flows through active evaporator and onto heater core.

   c. Heater control valve is modulated to closed position.

   d. Air flow rate is controlled by ram air or blower speed.

STACKED CORE REHEAT
(CHRYSLER)


FRESH OR RECIRCULATED AIR
TO COMPRESSOR
EPR VALVE
EVAPORATOR
EVAPORATOR COLD
EXPANSION VALVE
HEATER
ADJUSTABLE MODULATING WATER VALVE CONTROLS REHEAT
REHEATED BLENDED AIR INTO VEHICLE

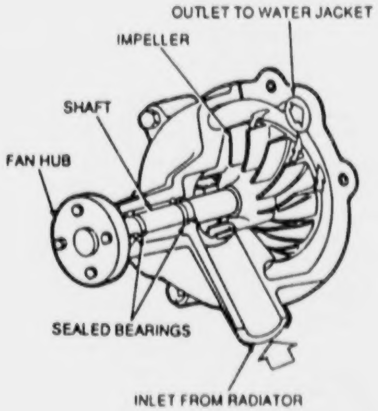
Courtesy of Murray Corporation

IV. Engine cooling system

A. The major engine cooling system components are the radiator, water (circulation) pump, thermostat, and cooling fan.

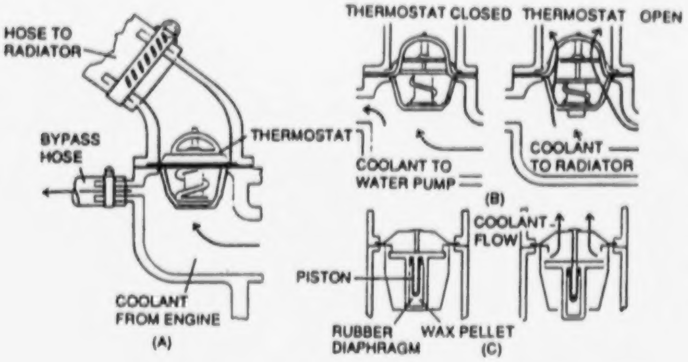
   1. The radiator is a heat exchange device that keeps engine coolant temperature within operating range.

   2. The water (circulation) pump is a nonpositive, displacement centrifugal pump, which is driven by the engine. The pump circulates the engine coolant throughout the cooling system.


OUTLET TO WATER JACKET
IMPELLER
SHAFT
FAN HUB
SEALED BEARINGS
INLET FROM RADIATOR

Courtesy of Chrysler Motors Corporation

3. The thermostat is a temperature-activated valve. When the coolant is cold, the thermostat is closed, thus restricting the coolant flow between the engine and radiator. The restriction of coolant flow caused by the closed thermostat allows the engine to warm up quickly and efficiently. When the coolant temperature reaches its normal operating temperature, the thermostat opens and the coolant is allowed to flow through the system.

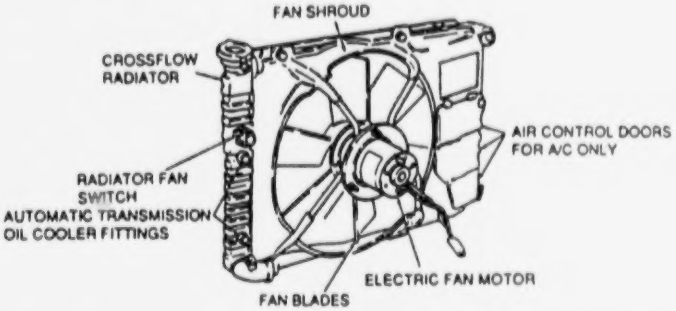

THERMOSTAT CLOSED
THERMOSTAT OPEN
HOSE TO RADIATOR
BYPASS HOSE
THERMOSTAT
COOLANT TO WATER PUMP
COOLANT TO RADIATOR
(B)
COOLANT FLOW
PISTON
COOLANT FROM ENGINE
(A)
RUBBER DIAPHRAGM
WAX PELLET
(C)

Courtesy of Napa

4. The cooling fan can be either a mechanical or electrical device. The cooling fan pulls air across the radiator fins during slow driving or hot engine operation.

   a. The mechanical cooling fan is attached to the water pump and driven by the engine. These fans are activated by a thermostatic clutch. When the engine becomes too hot, the clutch causes the fan to come on.

   b. The electric cooling fan is driven by an electric motor. A coolant sensing switch activates the fan when the engine reaches a specified temperature. The fan is also activated during operation of the air conditioner.


FAN SHROUD
CROSSFLOW RADIATOR
AIR CONTROL DOORS FOR A/C ONLY
RADIATOR FAN SWITCH
AUTOMATIC TRANSMISSION OIL COOLER FITTINGS
ELECTRIC FAN MOTOR
FAN BLADES

Courtesy of Chrysler Motors Corporation

B. Operation of the cooling system

1. During operation of the cooling system, the circulation pump pulls coolant from the bottom of the radiator and forces it through passages within the engine block where it absorbs heat. The coolant then flows upward toward the cylinder head. After leaving the cylinder head, the coolant (which still contains heat from the engine block) returns to the top of the radiator to cool. Once back in the radiator, the coolant is circulated again.

2. When the engine is cold, the thermostat (located at the coolant entrance to the block) restricts coolant flow. Even when the thermostat is closed, some coolant will enter the block through a bypass passage.

3. When the engine is cold and the thermostat is closed, the coolant from the upper part of the engine block is circulated to the heater core and returned to the lower portion of the engine block, thus ensuring an even warming of the engine.

MODULE: HEATING AND AIR CONDITIONING

UNIT VII: THE AUTOMOTIVE HEATING SYSTEM AND ENGINE COOLING SYSTEM

LESSON 2: DIAGNOSING AND REPAIRING AUTOMOTIVE HEATING SYSTEM PROBLEMS

I. Diagnosing a heating system that produces little or no heat

  A. A blockage or restriction in the vehicle's coolant system will cause the heater to produce little or no heat. Outlined below is the procedure for determining if there is a blockage or restriction within the system.

    1. Start the engine and let it warm up. Set the dash heater control on maximum heat.

    2. Compare the temperature of the inlet and outlet hoses on the heater core by touching them. If the heater is operating properly, the inlet hose should be hot and the outlet hose should be warm.

      a. If the heater core inlet hose is hot and the outlet hose is cold, the heater core may be blocked or the heater control valve may be stuck in the closed position.

      b. If both heater core hoses are warm, the outlet for the heater water pump or the heater hoses may be blocked. The heater core itself may also be blocked.

      c. If both hoses are hot, the heater core may be blocked or air may be failing to flow across the fins of the heater core.

  B. The failure of air to move across the vehicle's heater core (or an improper blend of hot and cold air moving across the core) will cause the heater to produce little or no heat. Outlined below is a procedure for determining if air is flowing properly across the fins of the heater core.

    1. Warm engine to operating temperature and, then, set the dash heater control on maximum heat.

    2. When moving the temperature control lever, note the operation of the system doors. If the lever controls the door by way of a vacuum, listen for the doors to open and close. If the lever controls the doors mechanically, simply observe the door movement.

    3. Observe the air conditioning clutch cycle. If it is cycling properly, test the controls on the instrument panel for proper operation according to the manufacturer's procedure.

    4. Check operation of blend door. The door should close the heater core bypass and allow all air to move over the heater core.

    5. Make sure heater control valve is operating properly.

    6. Check blower operation.

  C. Improper thermostat operation will cause the heater to produce little or no heat. Outlined below is a procedure for determining if the thermostat is operating improperly.

    1. Set the dash heater control on minimum heat.

2. Start the engine and compare the temperature of the upper and lower radiator hoses by touching them. At this time, both hoses should be relatively cool. If the thermostat is operating normally, the upper radiator hoses will begin to warm up while the lower hose remains cool. The thermostat will open when it reaches 180°F. After the thermostat opens, the lower hose should begin to increase in temperature until it too reaches 180°F.

   a. If the hoses warm up equally after the engine is started, then the thermostat is missing or stuck open. A new thermostat must be installed.

   b. If the top hose becomes extremely hot after the engine is started, then the thermostat is stuck in the closed position. A new thermostat must be installed.

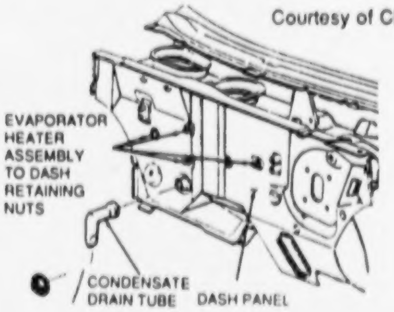
II. Diagnosing leaks within the heating system

A. Sometimes the condensation drain on the bottom of the plenum becomes plugged, resulting in a build-up of condensation. The build-up may cause the interior surface of the windshield to fog. Outlined below is a procedure for determining if there is excessive condensation build- up within the heating plenum chamber.

1. Back probe condensate drain to determine if it is blocked.

2. Make sure condensate opening is not deformed or flashed.

3. Make sure that the liquid exiting the condensate drain contains no antifreeze.



Courtesy of Chrysler Motors Corporation

B. Sometimes a leak can develop in the heater core. This condition also causes the interior surface of the windshield to fog. Outlined below is a procedure for determining if there is a leak within the heater core.

1. Pressure test cooling system to system pressure.

2. If anti-freeze is discovered inside the passenger compartment or is discharged from the condensate drain, repair or replace the heater core.

MODULE: HEATING AND AIR CONDITIONING

OPERATION OF AN AUTOMOTIVE HEATING SYSTEM

Instructions: **Do the following tasks and answer the following questions. Write all responses on this sheet.**

1. Define the following terms:

Blend door

Control doors

Dash control panel

Heater core

Plenum chamber

Thermostat

Vacuum motor

2. What warms the heater core by circulating through it?

3. What carries away heat by moving over and around the heater core?

4. Describe how a blend door mixes cool and hot air.

5. What heating system uses modulated control of the water valve?

6. The stacked-core system and the blend-air system differ in the arrangement of what two major heating system components?

7. In a blend-air system, what is the status of the air conditioning compressor when the control panel is set on maximum heat?

8. Describe the function of the thermostat during cold operation?

9. The engine water pump pulls coolant into the engine from which hose?

10. Describe how the heater hoses should feel to the touch (cold, warm, or hot) when the heater is set on maximum and the engine is fully warmed.

11. What heating system problem could cause one heater hose to be hot and the other cold, when the heater is set on maximum and the engine is fully warmed?

12. What can cause the inside of the windshield to fog when the defroster is running?

13. The thermostat should open when the engine coolant reaches what temperature?

MODULE: HEATING AND AIR CONDITIONING

OPERATION OF AN AUTOMOTIVE HEATING SYSTEM

(ANSWER SHEET)

1. A blend door is an air-flow control door that allows some air to bypass the heater core.

   Control doors are moveable doors that control the direction or rate of air flow through the heater and air conditioning plenum.

   The heating and air conditioning controls are mounted on the dash control panel.

   The heater core is a device that transfers heat from the engine coolant to the surrounding air, which then flows into the vehicle's passenger department.

   The plenum chamber is a housing that contains the heater core, evaporator, air-control doors, and blower motor.

   The thermostat is a coolant-control valve that allows or prevents coolant flow based upon engine temperature.

   The vacuum motor is a closed chamber with a rubber diaphragm in the middle.

2. Engine coolant

3. Air

4. The blend door can be positioned so that a portion of the air entering the plenum chamber moves over the heater core (and is, therefore, heated) while the remaining portion moves around the heater core (and, therefore, stays cool).

5. Blend air modulated water valve system

6. Heater core and evaporator coils

7. Not running

8. The thermostat restricts rate of coolant flow to help engine warm up more rapidly.

9. The bottom radiator hose

10. One hose should be hot and the other one warm.

11. Blocked heater core

12. A leak in the heater core or a clogged evaporator line

13. 180°F

MODULE: HEATING AND AIR CONDITIONING

DIAGNOSING AN AUTOMOTIVE HEATING SYSTEM

Equipment:

Service manual
Selected vehicle
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. _ _ _ _
2. Using the procedure outlined below, performance test the heater system. _ _ _ _
    a. Start vehicle and set heater control and blower speed on maximum. Allow the vehicle to warm up.
    b. Check one of the spaces below to indicate the temperature of inlet and outlet heater hoses after warm-up.

Inlet hose		Outlet hose	
___	Cool	___	Cool
___	Warm	___	Warm
___	Hot	___	Hot

    c. Make sure that air is coming from mode door indicated on the panel control. Record observations.

    d. Make sure that the blower motor is delivering air according to the rate indicated by the blower motor switch position. Record observations.

3. If the heater is producing little or no heat, use the information recorded above to determine the reason for the malfunction. — — — —

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency Hh1. Final evaluation for Hh1 will be made at the end of JS3-L2-UVII.)

JS2-L2-UVII

MODULE: HEATING AND AIR CONDITIONING

DIAGNOSING COOLANT LEAKS IN AN AUTOMOTIVE HEATING SYSTEM

Equipment:

Selected vehicle
Safety glasses
Replacement parts

	Procedure:	Evaluation 3	 2	 1	 N
1.	Wear safety glasses while doing all procedures on this job sheet.	___	___	___	___
2.	Pressurize coolant system to maximum system operating pressure.	___	___	___	___
3.	Observe coolant leakage from plenum housing or condensate drain. Record observations.	___	___	___	___
4.	Repair the leak or replace the faulty components.	___	___	___	___
	Average of above evaluations*	___	___	___	___

(*This average is a partial evaluation for Competency Hh1. Final evaluation for Hh1 will be made at the end of JS3-L2-UVII.)

MODULE: HEATING AND AIR CONDITIONING

DIAGNOSING THERMOSTAT MALFUNCTION IN AN AUTOMOTIVE HEATING SYSTEM

Equipment:

Selected vehicle
Safety glasses
Replacement parts

Procedure:	Evaluation 3 2 1 N
1. Wear safety glasses while doing all procedures on this job sheet.	__ __ __ __
2. Using the procedure outlined below, performance test the thermostat.	__ __ __ __

a. Warm up engine.

b. Touch upper and lower radiator hoses and compare their temperatures.

	Inlet	Outlet
Cold	_____	_____
Warm	_____	_____
Hot	_____	_____

(NOTE: Are the upper and lower radiator hoses equally warm while engine is running? If yes, thermostat may be stuck open and, therefore, require replacement.)

(NOTE: If the thermostat is operating normally, the upper radiator hoses will begin to warm up while the lower hose remains cool. The thermostat will open when it reaches 180°F. After the thermostat opens, the lower hose should begin to increase in temperature until it too reaches 180°F.)

Average of above evaluations* __ __ __ __

(*This average is a partial evaluation for Competency Hh1. Final evaluation for Hh1 will be made at the end of this job sheet.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency Hh1 by averaging the evaluations of JS1-L2-UVII, JS2-L2-UVII, and JS3-L2-UVII. Use the spaces provided below.

	Evaluation			
	3	2	1	N
JS1-L2-UVII	—	—	—	—
JS2-L2-UVII	—	—	—	—
JS3-L2-UVII	—	—	—	—
Final evaluation for Competency Hh1	—	—	—	—

MODULE: HEATING AND AIR CONDITIONING

UNIT VII: THE AUTOMOTIVE HEATING SYSTEM AND ENGINE COOLING SYSTEM

UNIT VII TEST

SECTION A: Match the terms below with their appropriate definitions.

____ 1. A closed chamber with a rubber diaphragm in the middle.

____ 2. A coolant-control valve that allows or prevents coolant flow based upon engine temperature.

____ 3. A device that transfers heat from the engine coolant to the surrounding air, which then flows into the vehicle's passenger compartment.

____ 4. A housing that contains the heater core, evaporator, air control doors, and blower motor.

____ 5. A device that brings engine coolant down to a specific operating temperature.

a. Blend door

b. Heater core

c. Plenum chamber

d. Radiator

e. Thermostat

ab. Vacuum motor

SECTION B: Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.

____ 6. Coolant always circulates from the lower side of the engine's cooling system, which is hotter, to the upper side (the radiator), which is cooler.

____ 7. When coolant is circulating within a vehicle's heating core, the outlet port of the core should be warmer than the inlet port.

____ 8. The blend-air system allows varying amounts of air to pass through the heater core fins.

____ 9. Blend-air systems with modulating water valves control air flow exactly like blend-air systems without modulating water valves.

____ 10. A vacuum signal or a cable controls the modulating water valve when the valve is used on blend-air systems.

____ 11. The modulating water valve on blend-air systems simply turns the coolant flow on and off.

____ 12. Most vehicle manufacturers are using stacked-core systems more and more frequently on late-model vehicles.

____ 13. Just like the blend-air system, the stacked-core system varies the amount of air passing over the heater core.

SECTION C. Match the terms below with their appropriate definitions.

____ 14. The circulation pump is driven by

a. the engine crankshaft.
b. the main drive shaft.
c. an electric motor.
d. ram air.
e. heat expansion.

____ 15. The engine thermostat is activated by

a. engine speed.
b. vehicle speed.
c. the engine choke.
d. the vacuum sensor.
e. engine temperature.

____ 16. A mechanical engine cooling fan is activated by a

a. solenoid.
b. vacuum sensor.
c. coolant sensing switch.
d. thermostatic clutch.
e. map sensor.

____ 17. An electric engine cooling fan is activated by a

a. solenoid.
b. vacuum sensor.
c. coolant sensing switch.
d. thermostatic clutch.
e. map sensor.

____ 18. During operation of the engine cooling system, the circulation pump pulls coolant from the

a. top of the radiator.
b. bottom of the radiator.
c. top and bottom of the radiator.
d. engine block.
e. coolant reservoir.

____ 19. After leaving the cylinder head, the coolant returns to the

a. top of the radiator.
b. bottom of the radiator.
c. top and bottom of the radiator.
d. engine block.
e. coolant reservoir.

____ 20. To ensure that a cold engine will warm evenly, the thermostat will close, causing

a. coolant in the lower engine block to circulate to the heater core and return to the upper engine block.
b. coolant in the upper engine block to circulate to the heater core and return to the lower engine block.
c. coolant flow to be diverted from the engine block.
d. coolant flow to be diverted from the heater core.
e. coolant flow to be diverted from the cylinder head.

SECTION D. Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.

____ 21. Blockage of coolant flow within the vehicle's heating system will cause air entering the passenger compartment to be too hot.

____ 22. If the heater is operating properly, its inlet hose should be hot and its outlet hose should be warm.

____ 23. If both the inlet and outlet heater hoses are hot, the heater core may be blocked.

____ 24. If the condensation drain (located on the bottom of the plenum) becomes plugged, the interior surface of windshield may fog.

____ 25. Liquid exiting the condensate drain should consist of at least 10% antifreeze.

(NOTE: The student must obtain a minimum score of ____ on the Unit VII in order to receive an evaluation for Competency Hh1.)

ANSWERS TO UNIT VII TEST

1.	ab
2.	e
3.	b
4.	c
5.	d
6.	f
7.	f
8.	t
9.	t
10.	t
11.	t
12.	f
13.	f
14.	a
15.	e
16.	d
17.	c
18.	b
19.	a
20.	b
21.	f
22.	t
23.	t
24.	t
25.	f

MODULE: HEATING AND AIR CONDITIONING

UNIT VIII: REPAIRING THE AUTOMOTIVE HEATING AND ENGINE COOLING SYSTEM

UNIT OBJECTIVE

After completing this unit, the student should be able to identify procedures for repairing a vehicle's heating and engine cooling system. The student will demonstrate mastery of the material by achieving a score of _____ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lesson in this unit, the student should be able to:

Lesson 1.

I. Identify procedures for inspecting, repairing, and replacing automotive heating system components (Competency Hh2, Unit VIII Test).

II. Identify procedures for inspecting, testing, and replacing the heater core coolant control valve (Competency Hh2, Unit VIII Test).

III. Identify procedures for pressure testing, inspecting, and repairing the engine coolant system (Competency Hh2, Unit VIII Test).

IV. Demonstrate the ability to:

   a. Inspect, test, and replace the heater core (Competency Hh2, JS1-L1-UVIII).

   b. Inspect, test, and replace the heater control valves (Competency Hh2, JS2-L1-UVIII).

   c. Inspect and repair the engine cooling system (Competency Hh2, JS3-L1-UVIII).

   d. Inspect, flush, and refill engine coolant (Competency Hh2, JS4-L1-UVIII).

   e. Inspect the engine cooling fan (Competency Hh2, JS5-L1-UVIII).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks G038-G045, G056 and H096.

MODULE: HEATING AND AIR CONDITIONING

UNIT VIII: REPAIRING THE AUTOMOTIVE HEATING AND ENGINE COOLING SYSTEM

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

  1. Lesson 1: PROCEDURES FOR REPAIRING THE VEHICLE'S HEATING SYSTEM AND ENGINE COOLING SYSTEM

    a. Information outline

    b. Assignment sheets

      AS1-L1-UVIII: Procedure for Removing the Heater Core
      AS2-L1-UVIII: Servicing the Heater Core and Engine Cooling System

    c. Job sheets

      JS1-L1-UVIII: Inspecting, Testing, and Replacing the Heater Core
      JS2-L1-UVIII: Inspecting, Testing, and Replacing the Heater Control Valves
      JS3-L1-UVIII: Inspecting and Repairing the Engine Cooling System
      JS4-L1-UVIII: Inspecting, Flushing, and Refilling Engine Coolant
      JS5-L1-UVIII: Inspecting the Engine Cooling Fan

E. Unit test

F. Answers to unit test

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Mitchell International, Inc. Automotive Air Conditioning Basic Service Training Manual. 21st ed. San Diego, CA: Mitchell International Inc., 1988.

Mitchell Manuals, Inc. 1984 Edition Automotive Air Conditioning Basic Service Training Manual. San Diego, CA: Mitchell Manuals, Inc., 1984.

Murray Corporation. Dealer Education Program Temperature Control Clinic Workbook. Cockeysville, MD: Murray Corporation, 1988.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit.

1. Students should do AS1-L1-UVIII in conjunction with JS1-L1-UVIII.

2. JS2-L1-UVIII involves inspecting and testing a heater control valve. Students should do the procedure under item 2 of JS2-L1-UVIII when servicing a vacuum control valve. Students should do the procedure under item 3 of JS2-L1-UVIII when servicing a manual control valve. Students do not need to do both procedures to complete the job sheet.

3. When performing JS5-L1-UVIII, students should do the procedure under item 2 when servicing a mechanical radiator fan; students should do the procedure under item 3 when servicing an electric radiator fan. Students do not need to do both procedures to complete the job sheet.

MODULE: HEATING AND AIR CONDITIONING

UNIT VIII: REPAIRING THE AUTOMOTIVE HEATING AND ENGINE COOLING SYSTEM

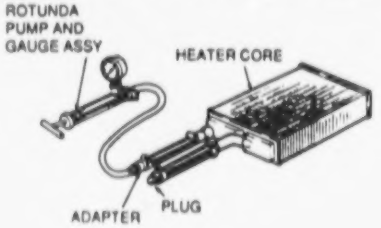
LESSON 1: PROCEDURES FOR REPAIRING THE VEHICLE'S HEATING SYSTEM AND ENGINE COOLING SYSTEM

I. Procedures for inspecting, pressure testing, flushing, and replacing heater core components

A. Procedure for pressure testing the heater core

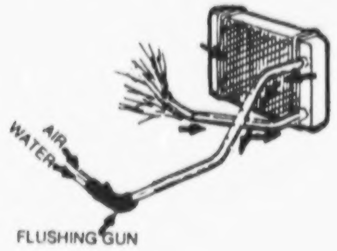
1. Remove the heater core from the vehicle.
2. Plug heater core outlet.
3. Attach pressure tester to heater core inlet.
4. Pump up to system pressure.
5. Submerge heater core in a tank of water.
6. Check for air bubbles indicating core leakage.

(CAUTION: Do not exceed 15 pounds of pressure when testing the heater core. Doing so may cause permanent damage to the heater core.)

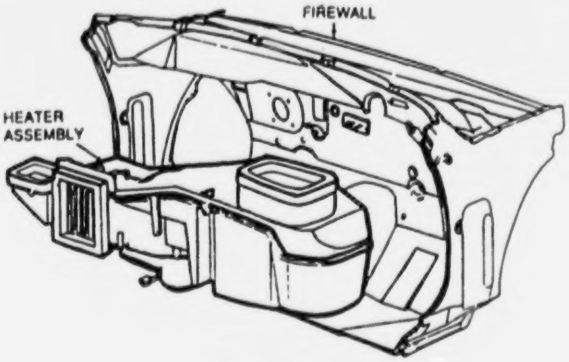


B. Procedure for flushing the heater core

1. Disconnect heater hoses at the engine.
2. Attach flush gun to one hose.
3. Begin flushing core with water and air. Do not flush at more than 15 psi.
4. Continue flushing core until water exiting the outlet hose is clear.



C. The procedure for replacing the heater core can vary. Locate and follow the manufacturer's procedure for the specific heater core to be serviced.



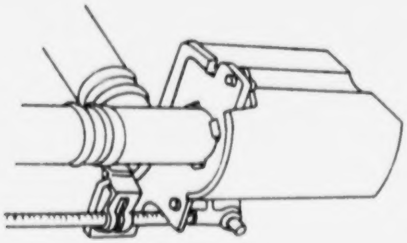
II. Procedures for inspecting, testing, and replacing the coolant control valve

A. Procedure for inspecting the manual coolant valve

1. Observe manual valve position.

2. Activate manual valve control on the dash and note if the manual valve responds correctly.

3. After activating manual valve control, touch the heater core to determine if a temperature change occurred at the outlet of the heater core.



B. Procedure for replacing manual coolant valve

1. Drain coolant from radiator.

2. Loosen valve clamps.

3. Disconnect heater hoses (by twisting them).

4. Replace valve.

5. Tighten the valve clamps.

(CAUTION: Overtightening hose clamps may cause the clamps to cut into the hose.)

C. Procedure for inspecting vacuum control valve

1. Remove vacuum hose from valve.

2. Attach vacuum pump.

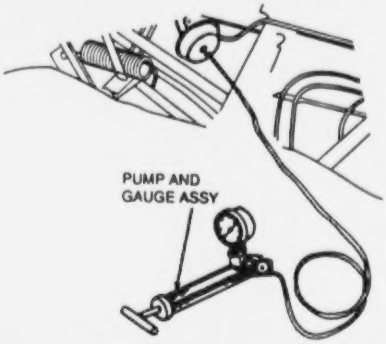
3. Start the engine and warm up.

4. Pump until 17 in Hg is obtained.

5. Watch for leaks in vacuum.

   (NOTE: Some valves have a built-in bleed hole and will leak coolant very slowly if the valve is defective.)

6. Feel for coolant temperature change in the heater core inlet hose.



D. Procedure for replacing the vacuum control valve

1. Drain coolant from radiator.

2. Loosen valve clamps.

3. Disconnect the heater hoses (by twisting them).

4. Replace valve.

5. Tighten the valve clamps.

   (**CAUTION:** Overtightening hose clamps may cause the clamps to cut into the hose.)

III. Procedures for pressure testing, inspecting, and repairing the engine cooling system

A. Procedure for testing cooling system pressure

1. Using a service manual, determine the correct operating pressure of the engine cooling system to be serviced.

2. Compare pressure of cap rating to pressure recommended by the manufacturer.

3. Attach cap to pressure tester and adapter.

   (NOTE: Follow the instructions with the tester.)

4. Pressurize the tester until the desired pressure is reached.

5. Watch for leak down. Pressure should reach 0 psi in 5 to 8 minutes.

   (NOTE: The pressure should remain at or close to the desired pressure and very slowly drop towards zero.)

6. Disconnect cap and adaptor from tester.

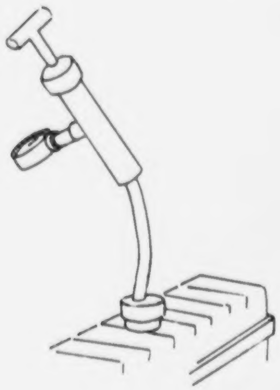
7. Attach tester to radiator filler neck.

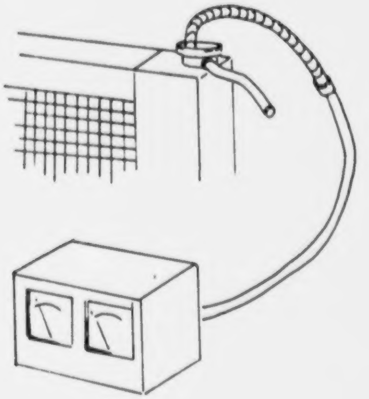
8. Pressurize the system until the desired pressure is reached.

9. Watch for leak down. Pressure should reach 0 psi in 5 to 8 minutes.

   (NOTE: The pressure should remain at or close to the desired pressure and very slowly drop towards zero.)

10. If system leaks down, check the following areas for leaks: hose connections; heater control valve; radiator seams and cores; water pump; and heater core. If no leaks are found, the loss may be occurring in the cylinder head or block. Test the cylinder head or block with an infra red tester or combustion gas detector.





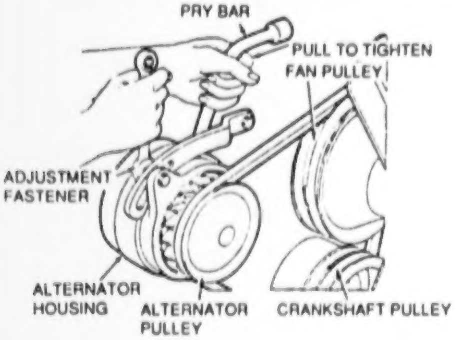
B. Procedure for inspecting and replacing belts on the engine cooling system

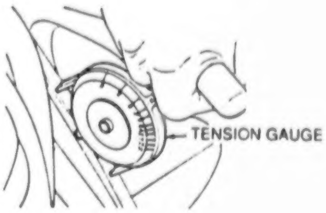
1. Inspect belts for proper fit.

2. Inspect belts for fraying, separation, glazing, cracks, and oil soaking. Also make sure the belts fit their pulleys.

3. Replace any belts that are found to be defective.

4. Using a tension gauge, tighten newly installed belts to manufacturer's specifications.





C. Procedure for determining freeze point of engine coolant

1. Using a hydrometer, draw a coolant sample into the float chamber of the coolant hydrometer.

2. Read the hydrometer scale or count the number of floating hydrometer balls.

3. Compare the hydrometer reading to the manufacturer's specifications to obtain freeze point of engine coolant.

4. Observe the color and condition of the coolant. If it is excessively dirty or badly contaminated, it should be replaced.

   (NOTE: Most manufacturers recommend that the cooling system be serviced every two years. New coolant should be added during service.)

D. Procedure for draining, flushing, and refilling engine cooling system

(NOTE: If the coolant system is extremely dirty, it is advisable to use a cooling system preflush in the system prior to flushing. Follow the instructions with the preflush.)

1. Slowly release system pressure at the radiator cap.

2. Open the system's petcock valve, and allow coolant to flow into a drain pan.

   (NOTE: Most petcock valves have left-handed threads.)

3. Disconnect both radiator hoses from the radiator.

4. Remove thermostat housing and thermostat.

5. Reinstall thermostat housing without thermostat.

6. Install the flush gun into the upper radiator hose.

7. Flush the system with water and air until clear water flows from the bottom hose.

   (NOTE: Be sure to open the heater core coolant valve.)

8. Disconnect both hoses from the engine and reconnect them to the radiator.

9. Install the flush gun into the upper radiator hose.

10. Flush the system with water and air until clear water flows from the bottom hose.

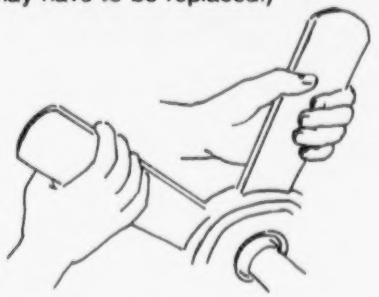
11. Reinstall thermostat and hoses. Fill system with approximately 50% antifreeze and 50% water.

E. Procedure for inspecting radiator fan clutch

1. Rock fan tips and note if they move. If fan tips move more than 1/4", replace the clutch.

2. Check for oil leaks around clutch shaft. If significant oil leaks are found, replace clutch shaft.

(NOTE: If the cooling system consistently overheats during stop-and-go driving, the clutch may have to be replaced.)



F. Procedure for checking operation of an electric radiator fan

1. Start vehicle engine.

2. Set air conditioning dash control on maximum cool. Cooling fan should start. If the fan fails to start, test its electrical circuit.

MODULE: HEATING AND AIR CONDITIONING

PROCEDURE FOR REMOVING THE HEATER CORE

Instructions: Do the following tasks on a separate sheet of paper.

(HINT: Use an appropriate service manual.)

1. Identify the type of heater core to be removed and the make, model, and year of the vehicle in which the heater core is used.
2. Develop a logically written procedure for removing the heater core identified in item 1 above.

MODULE: HEATING AND AIR CONDITIONING

SERVICING THE HEATER CORE AND ENGINE COOLING SYSTEM

Instructions: Do the following tasks and answer the following questions. Write all responses on this sheet.

1. During a test for leaks, how is the heater core pressurized while unattached from the system?

2. How much pressure should be applied to the heater core when it is tested for leaks while unattached from the system?

3. What two agents are used to flush the heater core?

4. How much time is required for the engine cooling system to leak down (how many psi in how many minutes)?

5. List five areas of the engine cooling system that should be inspected for leaks.

6. What device is used to test coolant for combustion gases that have been formed as a result of a blown head gasket?

7. What device is used to measure tightness of cooling system belts?

8. When used as engine coolant, antifreeze and water should be mixed in what proportions?

9. The electric cooling fan should come on when what electrical component is turned on?

MODULE: HEATING AND AIR CONDITIONING

SERVICING THE HEATER CORE AND ENGINE COOLING SYSTEM

(ANSWER SHEET)

1. The system is pressurized with air.
2. The heater core is pressurized at maximum system pressure.
3. Air and water
4. 0 psi in 5 minutes
5. Hose connections, heater control valve, radiator seams, water pump seal, heater core
6. Infrared tester or combustion detector
7. Belt tension gauge
8. 50% water and 50% antifreeze
9. Air conditioner

MODULE: HEATING AND AIR CONDITIONING

INSPECTING, TESTING, AND REPLACING THE HEATER CORE

Equipment:

Heater core pressure tester
Safety glasses
Sockets, wrenches, and other appropriate hand tools

Procedure:

		Evaluation 3 2 1 N
1.	Wear safety glasses while doing all procedures on this job sheet.	___ ___ ___ ___
2.	Following the procedure outlined below, pressure test the heater core.	___ ___ ___ ___

a. Complete AS1-L1-UVIII.

b. Connect tester fittings to one end of the heater core and plug the other end.

c. Pressurize heater core to maximum system pressure. Record observations.

d. Using the procedure developed in AS1-L1-UVIII, remove heater core.

e. Repeat steps b and c.

f. Submerge heater core in a tank of water and watch for air bubbles. Record observations.

g. Repair heater core or replace as needed.

3. Following the procedure outlined below, flush heater core. ___ ___ ___ ___

   a. Drain coolant system below core level.

   b. Disconnect inlet and outlet hoses at the back of the heater control valve.

   c. Put one hose into an open drain pan.

   d. Put flush gun into other hose and begin flushing heater core with air and water.

      (**CAUTION**: Do not exceed 15 psi of air pressure during flushing of the heater core. Flushing at more than 15 psi may damage the heater core.)

   e. Continue flushing heater core until liquid exiting core is clear.

4. Using the procedure developed in AS1-L1-UVIII, replace heater core. ___ ___ ___ ___

Average of the above evaluations* ___ ___ ___ ___

(*This average is a partial evaluation for Competency Hh2. Final evaluation for Hh2 will be made at the end of JS5-L1-UVIII.)

MODULE: HEATING AND AIR CONDITIONING

INSPECTING, TESTING, AND REPLACING HEATER CONTROL VALVES

Equipment:

Vacuum pump
Heater core pressure tester
Safety glasses
Sockets, wrenches, and other appropriate hand tools

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

   (NOTE: When servicing a vacuum control valve, do the procedure under item 2 below. When servicing a manual control valve, do the procedure under item 3 below.)

2. Using the procedure outlined below, inspect and test a vacuum heater control valve. ___ ___ ___ ___

   a. Remove the vacuum hose from the valve.

   b. Attach a vacuum pump to the valve.

   c. Operate vacuum pump until the pump gauge registers 17 inches of mercury.

   d. Watch for leak down.

   e. Start engine and operate heating system. Then check for equal temperature on each side of the valve. Record observations.

3. Using the procedure outlined below, inspect and test a manual heater control valve. ___ ___ ___ ___

   a. Note the position of the manual valve.

   b. Operate the dash-mounted manual valve control lever and note if manual valve moves correctly. Record observations.

c. Start the vehicle's engine. Touch both sides of the heater control valve to determine if the temperature is the same across the valve. Record observations.

4. Using the procedure outlined below, replace defective heater control valve. — — — —

a. Drain coolant below valve.

b. Remove the vacuum hose or the control cable.

c. Loosen clamps on valve.

d. Remove hoses from the valve by twisting gently.

e. Remove defective valve.

f. Reverse the above procedure in order to install a new valve.

g. Install new valve.

h. Tighten clamps.

(**CAUTION:** Overtightening the clamps can cause the clamp to cut through the hose.)

i. Reconnect the vacuum hose or control cable.

j. Refill the cooling system with fluid.

k. Start the vehicle and check the system for leaks.

Average of the above evaluations* — — — —

(*This average is a partial evaluation for Competency Hh2. Final evaluation for Hh2 will be made at the end of JS5-L1-UVIII.)

MODULE: HEATING AND AIR CONDITIONING

INSPECTING AND TESTING THE ENGINE COOLING SYSTEM

Equipment:

Pressure tester
Belt tension gauge
Sockets, wrenches, and other appropriate hand tools
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Using the procedure outlined below, pressure test radiator cap. ___ ___ ___ ___

   a. Using a service manual determine correct operating pressure of the engine cooling system to be serviced.

   b. Compare the service rating of cooling system pressure caps to the pressure recommended by the manual. Record observations.

   c. Attach cap to pressure tester and pressurize the tester until the pressure specified in the service manual is obtained.

   d. Watch for excessive leak down. Pressure should drop to 0 psi in 5 minutes. Record observations.

3. Using the procedure outlined below, pressure test the radiator and heater core. ___ ___ ___ ___

   (NOTE: Make sure the radiator is full of coolant.)

   a. Attach the pressure tester to the radiator filler neck.

   b. Pressurize the system until the pressure specified in the service manual is obtained.

   c. Watch for leak down (very little leak down should occur). Record observations.

d. If leak down occurs, check the items in the following list:

hose connections
heater control valve
radiator seams and cores
water pump seal
heater core
sending units
temperature control switches

e. If no leak is found, use an infrared tester or a combustion gas detector to test for the presence of combustion gas in the radiator.

4. Inspect the engine cooling system belts for loose threads, fraying, binding, or glazing. Record observations. _ _ _ _

5. Replace any defective belts found during the above inspection. The replacement belt should fit the criteria listed below. _ _ _ _

a. Make sure the replacement belt is the correct length and width.

b. Make sure the replacement belt is the correct design (v-belt, multirib, etc.).

c. Make sure the replacement belt has the correct service rating.

d. Using a belt tension gauge, tighten the replacement belt to manufacturer's specifications.

(NOTE: Tighten belt according to the procedure for the particular tension gauge being used.)

Average of the above evaluations* _ _ _ _

(*This average is a partial evaluation for Competency Hh2. Final evaluation for Hh2 will be made at the end of JS5-L1-UVIII.)

JS4-L1-UVIII

MODULE: HEATING AND AIR CONDITIONING

INSPECTING, FLUSHING, AND REFILLING ENGINE COOLANT

Equipment:

Drain pan
Freeze point tester
Selected vehicle
Funnel
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Following the procedure outlined below, make sure that engine coolant is at the proper level and has the proper freezing point. ___ ___ ___ ___

   a. Slowly remove cap to vent internal pressure.

      (**CAUTION:** Attempting to open a hot radiator can result in severe burns. Make sure radiator is cool before removing cap.)

   b. Inspect coolant level. Record observations.

      (NOTE: On nonrecovery systems, coolant level should be 1 to 2 inches below radiator neck to allow for coolant expansion. On recovery systems, coolant level should be flush with the radiator neck and flush with the cold level mark on the recovery tank.)

   c. Draw a sample of coolant into the coolant hydrometer.

      (NOTE: If fresh coolant was added to system in step 2 of this procedure, start engine and allow coolant to circulate and mix before measuring the freezing point.)

d. Compare the hydrometer reading to the manufacturer's specifications or the chart on the antifreeze container and determine if the freezing point of the coolant is sufficiently low. Add antifreeze as needed. Record observations.

3. Following the procedure outlined below, flush and refill the radiator. — — — —

a. Slowly remove the radiator cap to relieve system pressure.

(**CAUTION:** Attempting to open a hot radiator will result in severe burns. Make sure radiator is cool before removing cap.)

b. Open system petcock or remove lower radiator hose and allow coolant to drain. Capture coolant in a drain pan.

c. Disconnect lower radiator hose (if not already disconnected) from the radiator.

d. Remove thermostat housing and thermostat.

e. Reinstall housing without thermostat.

f. Disconnect upper radiator hose from the radiator and connect flush gun to the hose.

g. Flush the system with water and air until clear water flows from the lower radiator hose.

(NOTE: Be sure the coolant control valve is open.)

(NOTE: Do not exceed 15 psi air pressure when flushing the system.)

h. Reinstall thermostat using a new gasket.

i. Disconnect the upper radiator hose from the thermostat housing and connect it to the radiator.

j. Connect the flush gun to the upper radiator hose.

k. Disconnect the lower radiator hose from the engine block and connect it to the radiator.

l. Flush the system with water and air until clear water flows from the lower radiator hose.

(NOTE: Be sure the coolant control valve is open.)

(NOTE: Do not exceed 15 psi air pressure when flushing the system.)

m. Reinstall hoses and close petcock.

n. Fill system to appropriate level with a mixture of 50% antifreeze and 50% water.

o. Start the vehicle and check the system for leaks.

Average of the above evaluations* — — — —

(*This average is a partial evaluation for Competency Hh2. Final evaluation for Hh2 will be made at the end of JS5-L1-UVIII.)

MODULE: HEATING AND AIR CONDITIONING

INSPECTING THE ENGINE COOLING FAN

Equipment:

Selected vehicle
Safety glasses
Service manual

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __

(NOTE: Do the procedure under item 2 below when servicing a mechanical radiator fan. Do the procedure under item 3 below when servicing an electric radiator fan.)

2. Following the procedure outlined below, inspect the fan clutch. __ __ __ __

   a. Inspect clutch housing for signs of oil leaks. If leaks are found, replace housing. Record observations.

   b. Grasp radiator fan tip and rock fan back and forth. Replace fan if it rocks more than 1/4 of an inch. Record observations.

   (NOTE: Fan clutch should be replaced if it consistently overheats during stop and go driving.)

3. Following the procedure outlined below, inspect the electric radiator cooling fan. ___ ___ ___ ___

   a. Start engine and set air conditioner on maximum cool. Fan should begin to run. Record observations.

   b. If the electric cooling fan does not run, make the needed repairs to the system.

   Average of above evaluations*

   (This average is a partial evaluation for Competency Hh2. Final evaluation for Hh2 will be made below.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Competency Hh2 by averaging the evaluations of JS1-L1-UVIII, JS2-L1-UVIII, JS3-L1-UVIII, JS4-L1-UVIII, and JS5-L1-UVIII. Use the spaces provided below.

	Evaluation			
	3	2	1	N
JS1-L1-UVIII				
JS2-L1-UVIII				
JS3-L1-UVIII				
JS4-L1-UVIII				
JS5-L1-UVIII				
Final evaluation for Competency Hh2				

MODULE: HEATING AND AIR CONDITIONING

UNIT VIII: REPAIRING THE AUTOMOTIVE HEATING AND ENGINE COOLING SYSTEM

UNIT VIII TEST

SECTION A: Match the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.

____ 1. When the heater core is pressure tested, it should be emersed in water.

____ 2. During flushing of the heater core, heater hoses should remain connected to the engine.

____ 3. The heater core should be flushed with antifreeze.

____ 4. A clamp-on thermometer should be attached to the heater core as part of the procedure for determining if the core's manual coolant valve is functioning properly.

____ 5. The radiator does not have to be drained in order to replace a vacuum control valve within the heater core.

____ 6. Heater cores in many late-model automobiles use both a manual coolant valve and a vacuum-control valve.

____ 7. An infrared tester or combustion-gas detector can be used to test the cylinder head or block for signs of coolant leaks.

____ 8. Radiator fan belts are sufficiently tight if they do not slip off pulleys when the technician gives them a sharp tug.

____ 9. Before installation radiator fan belts should always receive a light coating of grease.

____ 10. A hydrometer is used to determine the freezing point of engine coolant.

____ 11. The engine's cooling system can be drained by opening its petcock valve.

____ 12. In order to flush the engine's cooling system, a flush gun should be installed into the thermostat housing opening.

____ 13. An engine's cooling system should typically be filled with approximately 75% water and 25% antifreeze.

____ 14. Significant oil leakage around radiator fan clutch can usually be repaired by replacing clutch seals.

____ 15. If radiator fan clutch consistently overheats during stop and go driving, the clutch bearings may need to be greased.

(NOTE: The student must obtain a minimum score of ____ on the Unit VIII Test in order to receive an evaluation for Competency Hh2.)

ANSWERS TO UNIT VIII TEST

1. t
2. f
3. f
4. f
5. f
6. f
7. t
8. f
9. f
10. t
11. t
12. t
13. f
14. f
15. f

MODULE: HEATING AND AIR CONDITIONING

UNIT IX: ELECTRICAL COMPONENTS OF AUTOMOTIVE AIR CONDITIONING AND HEATING SYSTEMS

UNIT OBJECTIVE

After completing this unit, the student should be able to inspect, test, and repair heating and cooling systems. The student will demonstrate mastery of the material by achieving a score of ____ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lesson in this unit, the student should be able to:

Lesson 1.

I. Identify terms and definitions associated with electrical components of automotive air conditioning and heating systems (Competency Gg4, Unit IX Test).

II. Identify the various types of automotive air conditioning switches and the principles by which they operate (Competency Gg4, Unit IX Test).

III. Identify various types of air conditioning load devices and the principles by which they operate (Competency Gg4, Unit IX Test).

IV. Identify testing procedures for typical air conditioning circuits (Competency Gg4, Unit IX Test).

V. Demonstrate the ability to:

  a. Diagnose and repair a switch circuit (Competency Gg4, JS1-L1-UIX).

  b. Diagnose and repair load devices (Competency Gg4, JS2-L1-UIX).

  c. Test electrical air conditioning control units (Competency Gg4, JS3-L1-UIX).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit can be adapted to cover ASE tasks G046,G047,G048,G050, and G051.

MODULE: HEATING AND AIR CONDITIONING

UNIT IX: ELECTRICAL COMPONENTS OF AUTOMOTIVE AIR CONDITIONING AND HEATING SYSTEMS

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

  1. Lesson 1: ELECTRICAL COMPONENTS

    a. Information outline

    b. Assignment sheets

      AS1-L1-UIX: Description of Electrical Components

    c. Job sheets

      JS1-L1-UIX: Diagnosing and Repairing a Switch Circuit
      JS2-L1-UIX: Diagnosing and Repairing Load Devices
      JS3-L1-UIX: Testing Electrical Air Conditioning Control Units

E. Unit test

F. Answers to unit test

REFERENCES

Carter Carburetor Division, ACF Industries, Inc. Automotive Air Conditioning Theory and Practice.

Mitchell Information Services, Inc. Heating and Air Conditioning Systems. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1987.

Mitchell International, Inc. Automotive Air Conditioning Basic Service Training Manual. 21st ed. San Diego, CA: Mitchell International Inc., 1988.

Mitchell Manuals, Inc. 1984 Edition Automotive Air Conditioning Basic Service Training Manual. San Diego, CA: Mitchell Manuals, Inc., 1984.

Murray Corporation. Dealer Education Program Temperature Control Clinic Workbook. Cockeysville, MD: Murray Corporation, 1988.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Students should do AS1-L1-UIX before taking the Unit IX Test.

MODULE: HEATING AND AIR CONDITIONING

UNIT IX: ELECTRICAL COMPONENTS OF AUTOMOTIVE AIR CONDITIONING AND HEATING SYSTEMS

LESSON 1: ELECTRICAL COMPONENTS

I. Terms and definitions

A. Blower motor resistor--A group or series of resistors that limit current to the blower motor. Blower motor speed will vary, depending on the size of the resistor through which electrical current passes. (The blower motor control on the dash directs the current through various sizes of resistors.)

B. Circuit breaker--A circuit protection device that opens when current rate is in excess of the breaker rating. The breaker will automatically reset after the excessive current draw is removed.

C. Current draw--The amount of current that can be forced through an electrical circuit at a given voltage.

D. Fuse--A circuit protection device that destructs at a predetermined current rate.

E. Ground circuit--A short between two conductors of the same potential.

F. Load device--The part of the electrical circuit that produces work. The load device provides a voltage drop in the circuit to prevent the power supply (battery) from shorting to ground.

G. Open circuit--A break in an electrical circuit. An open is often thought of as an undesirable break; however, an open will also result from turning off an electrical switch.

H. Parallel circuit--A circuit in which the components share a common beginning and a common end. In the parallel circuit, current is equally available to all components of the circuit at the same time.

I. Relay--An electrical switching device that relays current flow through a set of contacts when the switching coil is energized.

J. Series circuit--A circuit in which the components are attached end to end. Current must pass through one component before going to the next.

K. Sensor--An electrical device that senses various conditions such as pressure, temperature, position, and, as a result, produces an electrical signal.

L. Short circuit--Leaking of current to ground before the current has fully accomplished its work. Shorts will cause circuit failure and blow circuit protection devices.

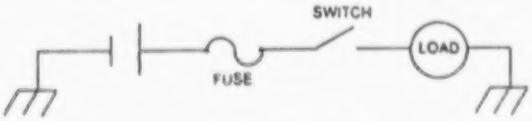
M. Thermistor--A type of sensor that changes its resistance on the basis of temperature and, therefore, produces a varying voltage drop across the thermistor to ground.

II. Automotive air conditioning switches

(NOTE: Air conditioning switches generally fall into the following three categories: power side switches; ground side switches; and relay switches. Each category of switches requires a different testing procedure; therefore, an air conditioning switch must be identified as belonging to one of these three categories before testing.)

A. Power side switch

1. In a power side switch, current passes through the switch before continuing through the load device.

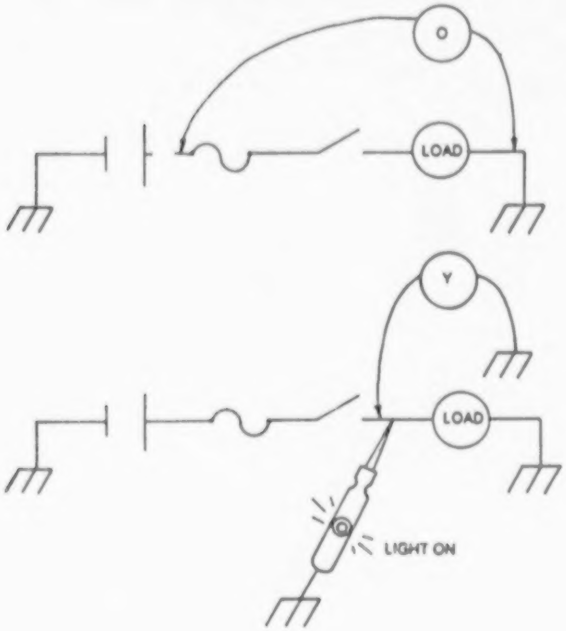


2. Procedure for testing a power side switch

   a. A power side switch can be tested with either a voltmeter, a testlight, or an ohmmeter.

   b. The below illustration shows how to connect a voltmeter, a testlight, and an ohmmeter when testing for a closed switch in the circuit.

   (NOTE: Only use an ohmmeter on disabled circuits. The ohmmeter reading should be close to zero.)



B. Ground side switch

1. The ground side switch completes the circuit by grounding the circuit.

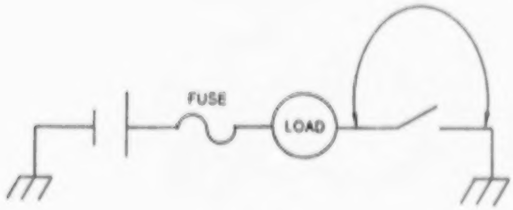
2. Procedure for testing a ground side switch

   a. The ground side switch can be tested with a jumper wire or an ohmmeter.

AC Fig 8-3

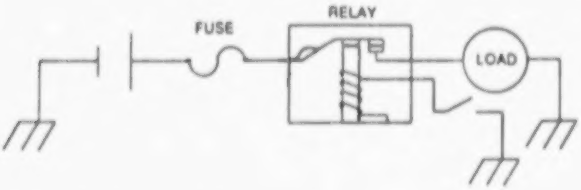
b. The below illustration shows how to connect a voltmeter, a testlight, and an ohmmeter when testing for a closed switch in the circuit.

(NOTE: Only use an ohmmeter on disabled circuits. The ohmmeter reading should be close to zero.)



C. Relay switch

1. A relay switch combines series switch action with a magnetic coil. When the coil is energized, the switch closes and completes the circuit.



2. Procedure for testing a relay switch

(NOTE: The procedure for testing the relay switch involves testing for proper relay and switching action. This procedure is, therefore, more complex than those used for testing the other switches.)

a. Using a schematic, determine if the relay coil is energized by a switch located on the source or the ground side of the coil.

b. Jump the switch with power on. The relay should close. Replace the relay if it remains open.

c. Using a testlight or voltmeter, test for continuity through the relay switch when it is closed. Replace the relay if no power passes through it.

d. If power does pass through the relay, activate the relay switch to test relay action.

e. If the relay switch fails to activate the relay, test the switch for proper action, according to the series switch or grounding switch procedure.

III. Air conditioning load devices

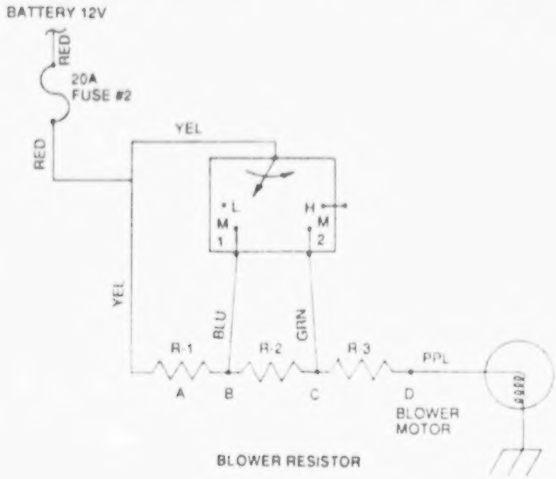
(NOTE: Air conditioning load devices fall into three categories: magnetic-field-producing loads; electromagnetic loads; and series-resistance voltage-dropping loads.)

A. Magnetic-field-producing loads

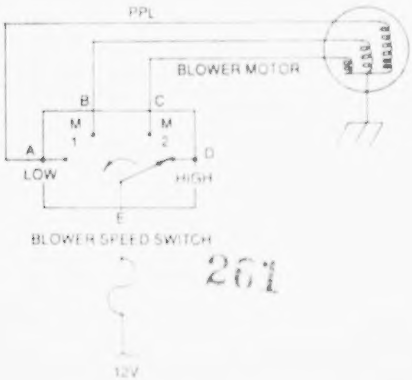
1. In magnetic-field-producing loads, current passes through the coil of the relay and creates a magnetic field. (The relay switch discussed above is a magnetic field producing device.) This magnetic field pulls the moveable contact arm down, establishing contact between the switch contacts.

2. An electric motor is an example of a magnetic field being used as an electrical load device. The electric motor uses current to create an internal magnetic field that, in turn, rotates an armature shaft. The length and size of windings used in the motor determine the amount of current that can pass through the motor. Low resistance windings allow large amounts of current to pass through the windings. High resistance windings limit the current flow. There are two types of electric motors: the single-field and multiple-field motor.

    a. The single-field electric motor is a brushed motor, which uses a set of field windings. The motor's speed is determined by the amount of voltage the motor receives. The motor's speed can, therefore, only be altered if the amount of voltage supplied to the motor is altered.



    b. The multiple-field motor may use up to three sets of field windings, with each winding differing in length or size. Each set of windings or combination of windings will run the motor at a different speed.



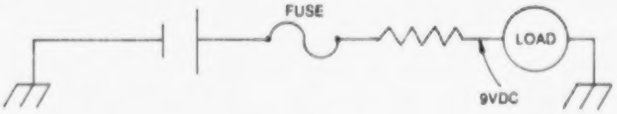
B. Electromagnetic loads

1. Electromagnetic loads use electricity to produce an electromagnet, which attracts metal pieces in a mechanical device.

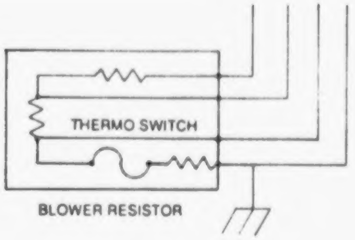
2. The air conditioning compressor clutch is a good example of an electromagnetic load. Current passes through the clutch coil creating a dense magnetic field. The field pulls the flex plate into the pulley, thus locking the compressor shaft and pulley together. With the compressor shaft and pulley locked together, the compressor can be driven.

C. Series-resistance voltage-dropping loads

1. The voltage drop caused by the resistors is used to divide (and thus reduce) incoming voltage before it reaches a load device.


FUSE
LOAD
9VDC

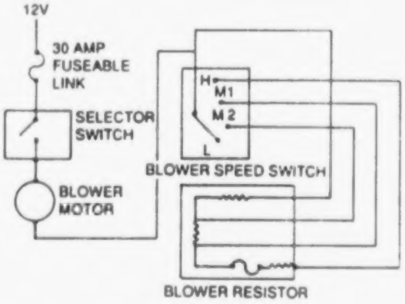
2. The voltage drop caused by the resistor is very useful in controlling load devices. For example, a single-field motor (the speed of which is determined solely by incoming voltage) can be run at three different speeds if voltage dropping resistors can divide the incoming voltage into three different levels.


THERMO SWITCH
BLOWER RESISTOR

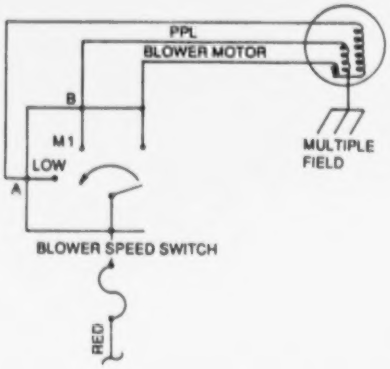
IV. Testing procedures for typical air conditioning circuits

A. Air conditioning heater blower circuit

1. Typical single-field


12V
30 AMP
FUSEABLE
LINK
SELECTOR
SWITCH
BLOWER
MOTOR
H
M1
M2
L
BLOWER SPEED SWITCH
BLOWER RESISTOR

2. Typical multiple-field



3. Procedure for testing a typical blower

    a. Determine current path from the system schematic.

    b. Check for blown fuses. Replace any blown fuses and then test system operation.

    c. Using a testlight or voltmeter, check for voltage at the motor connector. If present, resistance test the motor input leads for correct resistance. The resistance should be less than infinite but not 0 ohms.

    d. If no voltage or a low voltage is present at the motor connector, test for voltage at the resistor pack or motor terminal.

    e. If voltage is available to the resistor pack, test the resistor.

    f. If voltage is available to the control switch on the multiple-field motor, test the resistance of the switch assembly.

    g. The resistance should be less than infinite, but not zero. If the resistance of the resistor pack and/or motor is adequate, test the source voltage.

B. Procedure for testing air conditioning compressor clutch circuit

1. Determine clutch current path from system schematic.

2. Check air conditioning fuses. Replace any blown fuses and test system performance.

3. Using a testlight, test for voltage at the compressor clutch. If voltage is present, resistance test clutch coil. Resistance should be less than infinite but more than 0 ohms.

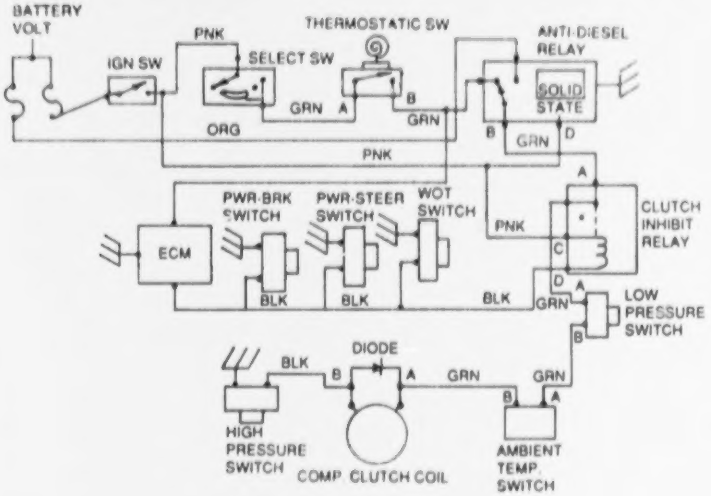
4. If voltage is not present at the compressor clutch, test the relay. If relay is good, test clutch pressure cycling switch according to series switch test.

5. If cycling switch is good, test circuit for opens.

6. If circuit contains no opens, test air conditioning control switch.

7. If air conditioning control switch is good, test throttle cutout switch.

8. If the throttle cutout switch is good, test the voltage source.


BATTERY VOLT
IGN SW
PNK
SELECT SW
THERMOSTATIC SW
ANTI-DIESEL RELAY
SOLID STATE
GRN
A
B
GRN
ORG
B
GRN
D
PNK
A
ECM
PWR-BRK SWITCH
PWR-STEER SWITCH
WOT SWITCH
PNK
CLUTCH INHIBIT RELAY
C
D
A
BLK
BLK
BLK
GRN
LOW PRESSURE SWITCH
B
DIODE
BLK
B
A
GRN
GRN
B
A
HIGH PRESSURE SWITCH
COMP. CLUTCH COIL
AMBIENT TEMP. SWITCH

C. Procedure for testing air conditioning cooling fan circuit

1. Determine current path from system schematic.

2. Check cooling fan fuses. Replace any blown fuses and then test system operation.

3. Put dash control on maximum air conditioning and ground coolant sensor wire. Cooling fan should run. If coolant fan runs, replace sensor.

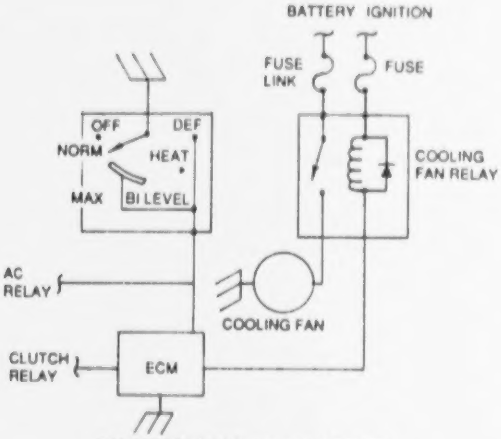
4. If the coolant fan does not run after grounding the coolant sensor wire, test for voltage at the blower connection. If voltage is present, resistance test fan motor.

5. If fan motor resistance is adequate, test the fan relay.

6. If the relay is good, test the circuit for opens.

7. If there are no opens in the circuit, test the air conditioner control switch.

8. If the air conditioning control switch is good, test the power source.


BATTERY
IGNITION
FUSE LINK
FUSE
OFF
DEF
NORM
HEAT
MAX
BI LEVEL
COOLING FAN RELAY
AC RELAY
COOLING FAN
CLUTCH RELAY
ECM

G.M. "A" BODY COOLING FAN CIRCUITS

MODULE: HEATING AND AIR CONDITIONING

DESCRIPTION OF ELECTRICAL COMPONENTS

Instructions: **Do the following tasks and answer the following questions. Write all responses on this sheet.**

1. Define the following terms:

Blower motor resistor

Load device (electrical)

Open (electrical)

Parallel circuit

Relay (electrical)

Series circuit

Sensor

Short

2. Name the three types of electrical switching devices.

3. Name three important types of electrical test instruments used in automotive electrical testing.

4. Describe how a power side switch controls a circuit.

5. When energized, how does a relay switch complete a circuit?

6. Name two types of electrical load circuits used in air conditioning systems.

7. What meter reading would indicate that the compressor clutch coil has an open in it?

8. What two devices usually control a cooling fan circuit?

MODULE: HEATING AND AIR CONDITIONING

DESCRIPTION OF ELECTRICAL COMPONENTS

(ANSWER SHEET)

1. A blower motor resistor is a bank or series of resistors that limit voltage to the blower motor.

   A load device is the part of the electrical circuit that produces work.

   An open or a break in an electrical circuit

   The components in a parallel circuit share a common beginning and a common end; therefore, current is equally available to all components of the circuit at the same time.

   A relay is an electrical switching device, which relays current flow through a set of contacts when the switching coil is energized.

   In the series circuit, the components are attached end to end; therefore, current must pass through one component before going on to the next.

   A sensor is an electrical device that senses various conditions such as pressure, temperature, position, and, as a result, sends an electrical signal.

   When a short occurs in an electrical circuit, current leaks to ground before fully accomplishing its work.

2. Power side switch, ground side switch, and relay switch

3. Test light, voltmeter, and ohmmeter

4. The power side switch opens and closes the circuit before the load device.

5. A magnetic field is created; the magnetic field pulls the relay switch closed, thus closing a set of contacts.

6. Magnetic-field-producing circuits and series-resistance circuits

7. Infinite

8. A relay and coolant sensor

JS1-L1-UIX

MODULE: HEATING AND AIR CONDITIONING

DIAGNOSING AND REPAIRING A SWITCH CIRCUIT

Equipment:

VOM
Jumper wire
Service manual
Selected circuits
Testlight
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Using the procedure outlined below, test a power side switch. ___ ___ ___ ___

   a. Locate a power side switch for testing.

   b. Trace current path and draw circuits in the space provided.

   c. Using a voltmeter, test for the presence of voltage at test points before and after the switch. Draw a diagram of the voltmeter setup below. Record observations.

   d. Using a testlight, test for the presence of voltage in the circuit. (Test the same test points as in the above voltmeter test.) Draw a diagram of the testlight setup below. Record observations.

e. Using an ohmmeter set on RXl or 200 ohm scale, test for continuity across the switch. Draw a diagram of the testlight setup below. Record observations.

(**CAUTION:** Remove power from switch before testing.)

3. Using the procedure outlined below, test a ground side switch. — — — —

a. Locate a ground side switch for testing.

b. Trace the current path and draw the circuit in the space provided below.

c. Using the jumper wire, jump the ground side switch with the circuit energized. The load device should come on. Record observations and draw a diagram of the jumper wire setup below.

d. Use an ohmmeter to test continuity of the ground side switch while the switch is disconnected. Record observations and draw a diagram of the jumper wire setup below.

(NOTE: The switch must be removed from the circuit for testing.)

4. Using the procedure outlined below, test an electromagnetic relay. — — — —

a. Locate an electromagnetic relay for testing.

b. Trace the current path and draw the circuit in the space provided below. Determine if the relay coil is energized by a power side switch or a ground side switch. Record observations.

c. With the circuit energized, jump the relay control circuit with a jumper. The relay should activate. If relay does not activate, test for power to the relay with a voltmeter. Record observations and draw a diagram of the jumper wire setup below.

d. With relay energized, use a voltmeter or testlight to test switch action. Record observations and draw a diagram of the voltmeter or testlight setup below.

Average of the above evaluations* ____

(*This average is a partial evaluation for Competency Gg4. Final evaluation for Gg4 will be made at the end of JS4-L1-UXI.)

JS2-L1-UIX

MODULE: HEATING AND AIR CONDITIONING

DIAGNOSING AND REPAIRING LOAD DEVICES

Equipment:

VOM
Service manual
Selected circuits
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Using the procedure outlined below, test a field load device. ___ ___ ___ ___

   a. Locate a field load device for testing.

   b. Trace the current path through the schematic and draw the circuit in the space provided below.

   c. Locate fuses. Determine and record the amperage of the fuses.

   d. Disconnect load from circuit.

   e. Connect ohmmeter to the load device and measure resistance of the load device. Using Ohm's law, determine if series resistance falls below the fuse protection of the circuit. Record calculations and draw a diagram of the ohmmeter setup below.

      Calculated resistance _____

      Measured resistance _____

3. Using the procedure outlined below, test resistance of a blower motor resistor pack. ___ ___ ___ ___

a. Locate a blower motor resistor pack for testing.

b. Trace the current path through the resistor pack and draw the circuit in the space provided below.

4. Energize circuit and, using a voltmeter, measure voltage drop across resistors. Record observations and draw a diagram of the ohmmeter setup below.

Voltmeter readings ________

____

____

____

Average of the above evaluations* — — — —

(*This average is a partial evaluation for Competency Gg4. Final evaluation for Gg4 will be made at the end of JS4-L2-UXI.)

MODULE: HEATING AND AIR CONDITIONING

TESTING ELECTRICAL AIR CONDITIONING CONTROL UNITS

Equipment:

Selected circuits
Service manual
VOM
Jumper wire
Testlight
Safety glasses

Procedure:

Evaluation
3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __

2. Using the procedure outlined below, test the heater blower circuit. __ __ __ __

   a. Locate the heater blower circuit for testing.

   b. Using a service manual schematic, trace current path through the heater blower circuit and draw the circuit in the space provided below.

   c. Using the appropriate test procedure, diagnose faults in the blower circuit. Make all necessary repairs. Record any repairs made.

   d. Performance test circuit and confirm blower operation. Record observations.

3. Using the procedure outlined below, test the air conditioning compressor clutch circuit. ____

    a. Locate a compressor clutch circuit and test.

    b. Using a service manual schematic, trace the current path of the compressor clutch circuit and draw the circuit in the space provided below.

    c. Using appropriate test procedures, diagnose the compressor clutch circuit. Repair as needed and record any repairs made.

    d. Performance test circuit and confirm compressor clutch operation. Record observations.

4. Using the procedure outlined below, test an air conditioning compressor cutout control circuit. ____

    a. Locate a compressor clutch cutout control circuit for testing.

    b. Using a service manual schematic, trace the current path of the compressor cutout control circuit and draw the circuit in the space provided below.

    c. Using appropriate test procedures, diagnose the compressor cutout control circuit. Repair as needed and record any repairs made.

d. Performance test circuit and confirm operation of compressor cutout control. Record observations.

5. Using the procedure outlined below, test the engine cooling fan circuit. — — — —

    a. Locate the engine cooling fan circuit.

    b. Using a service manual schematic, trace current path of the engine cooling fan circuit and draw in the space provided below.

    c. Using the appropriate test procedure, diagnose the engine cooling fan circuit. Repair as needed and record any repairs made.

    d. Performance test circuit and confirm operation of engine cooling fan. Record observations.

Average of the above evaluations* — — — —

(*This average is a partial evaluation for Competency Gg4. Final evaluation for Gg4 will be made at the end of JS4-L2-UXI.)

MODULE: HEATING AND AIR CONDITIONING

UNIT IX: ELECTRICAL COMPONENTS OF AUTOMOTIVE AIR CONDITIONING AND HEATING SYSTEMS

UNIT IX TEST

SECTION A. Select the best answer from the five choices listed.

____ 1. The amount of current that can be forced through an electrical load at a given voltage can be referred to as

a. current draw.
b. wattage.
c. AC current.
d. DC current.
e. ampere seconds.

____ 2. The type of air conditioning switch that current enters and exits before continuing through the circuit is a

a. power side switch.
b. ground side switch.
c. relay switch.
d. moveable pole switch.
e. permanent pole switch.

____ 3. A magnetic coil is an important part of a

a. power side switch.
b. ground side switch.
c. relay switch.
d. moveable pole switch.
e. permanent pole switch.

____ 4. The grounding switch can be tested with a

a. jumper wire or an ohmmeter.
b. jumper wire or a voltmeter.
c. jumper wire or an ammeter.
d. jumper wire or a testlight.
e. jumper wire only.

____ 5. A thermistor changes its resistance on the basis of

a. external pressure.
b. magnetic attraction.
c. direction of current flow.
d. temperature.
e. specific gravity.

____ 6. An electric motor uses current to create an internal magnetic field that, in turn, rotates

a. a control arm.
b. a magnetic coil.
c. a solenoid.
d. a contact switch.
e. an armature shaft.

____ 7. Electric motors use either

a. stationary or oscillating magnetic polarity.
b. single or multiple magnetic fields.
c. permanent or rotating magnets.
d. vertical or horizontal windings.
e. stacked or in-line stators.

____ 8. A good example of an electromagnetic load is

a. a plenum chamber.
b. an engine cooling fan.
c. a thermistor.
d. an air conditioning compressor clutch.
e. an air-blend door.

____ 9. The voltage-dropping resistor is most often used to divide (and thus reduce) voltage before it reaches a

a. load device.
b. control device.
c. grounding device.
d. circuit protection device.
e. circuit insulating device.

SECTION B: **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 10. Testing a relay is a more complex procedure than testing other types of switches used in air conditioning systems.

____ 11. Power side switches, ground side switches, and relay switches are all categories of air conditioning switches.

____ 12. In some types of electric motors, a winding or a combination of windings is used to run the motor at different speeds.

____ 13. When the coil on a relay switch is energized, the switch opens and interrupts current flow in the circuit.

____ 14. Voltage dropping resistors allow electric motors to run only at one speed.

____ 15. A power side switch can be tested with either a voltmeter, a testlight, or an ohmmeter.

(NOTE: The student must obtain a minimum score of ____ on the Unit IX Test in order to receive an evaluation for Competency Gg4.)

ANSWERS TO UNIT IX TEST

1. a
2. a
3. c
4. a
5. d
6. e
7. b
8. d
9. a
10. t
11. t
12. t
13. f
14. f
15. f

MODULE: HEATING AND AIR CONDITIONING

UNIT X: DIAGNOSING AND REPAIRING AUTOMOTIVE HEATING AND AIR CONDITIONING CONTROL DEVICES

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose and repair automotive heating and air conditioning control devices. The student will demonstrate mastery of the material by achieving a score of _____ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lesson in this unit, the student should be able to:

Lesson 1.

I. Identify terms and definitions associated with automotive heating and air conditioning control devices (Competency Gg4,Unit X Test).

II. Identify the principles by which vacuum switches, solenoids, and reservoirs operate (Competency Gg4,Unit X Test).

III. Identify the principles by which a vacuum motor operates (Competency Gg4, Unit X Test).

IV. Identify the principles by which mechanical cable and mechanical linkage operate (Competency Gg4, Unit X Test).

V. Identify the principles by which the plenum system operates (Competency Gg4, Unit X Test).

VI. Identify the procedures for inspecting and testing vacuum and mechanical control units (Competency Gg4, Unit X Test).

VII. Demonstrate the ability to:

   a. Test vacuum control units (Competency Gg4, JS1-L1-UX).

   b. Test vacuum reservoir and check-valve (Competency Gg4, JS2-L1-UX).

   c. Test mode door operation and mechanical linkage (Competency Gg4, JS3-L1-UX).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks G052, and G054-G057.

MODULE: HEATING AND AIR CONDITIONING

UNIT X: DIAGNOSING AND REPAIRING AUTOMOTIVE HEATING AND AIR CONDITIONING CONTROL DEVICES

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

  1. Lesson 1: AUTOMOTIVE HEATING AND AIR CONDITIONING CONTROL DEVICES

    a. Information outline

    b. Assignment sheets

      AS1-L1-UX: Heating and Air Conditioning Control Devices
      AS2-L1-UX: Procedure for Dash Removal

    c. Job sheets

      JS1-L1-UX: Testing Vacuum Control Units
      JS2-L1-UX: Testing Vacuum Reservoir and Check Valve
      JS3-L1-UX: Testing Mode Door Operation and Mechanical Linkage

E. Unit test

F. Answers to unit test

REFERENCES

Carter Carburetor Division, ACF Industries, Inc. Automotive Air Conditioning Theory and Practice.

Mitchell Information Services, Inc. Heating and Air Conditioning Systems. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1987.

Mitchell International, Inc. Automotive Air Conditioning Basic Service Training Manual. 21st ed. San Diego, CA: Mitchell International Inc., 1988.

Mitchell Manuals, Inc. 1984 Edition Automotive Air Conditioning Basic Service Training Manual. San Diego, CA: Mitchell Manuals, Inc., 1984.

Murray Corporation. Dealer Education Program Temperature Control Clinic Workbook. Cockeysville, MD: Murray Corporation, 1988.

NOTES TO THE INSTRUCTOR

I. Suggested approaches to teaching this unit

   A. Students should do AS1-L1-UX before taking the Unit X test. Students should do AS2-L1-UX in conjunction with JS1-L1-UX.

MODULE: HEATING AND AIR CONDITIONING

UNIT X: DIAGNOSING AND REPAIRING AUTOMOTIVE HEATING AND AIR CONDITIONING CONTROL DEVICES

LESSON 1: AUTOMOTIVE HEATING AND AIR CONDITIONING CONTROL DEVICES

I. Terms and definitions

A. Air door (air inlet)--A moveable door that directs air flow within a plenum chamber.

B. Bilevel air flow--Heated or cooled air coming from the floor and dash registers simultaneously.

C. Cable--A wire that connects the dash heater control with the air control doors.

D. Defrost door--An air door that directs plenum air to defrost registers.

E. Heater control panel--A dash-mounted control panel that allows the driver to adjust the mode of operation and the temperature setting of the vehicle's heater and the air conditioner.

F. Plenum chamber--A Housing that contains components of the heating and air conditioning system, such as the heater core, evaporator, control doors, and blower.

G. Registers--Outlets through which air from the vehicle's heating and air conditioning systems enters the passenger compartment.

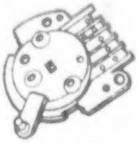
H. Temperature control cable--A cable that connects the temperature lever on the control panel to the temperature control door in the plenum. The temperature control door is moved by the temperature control cable.

I. Vacuum control--A diaphragm that moves as a result of the creation of a vacuum. The vacuum control can open and close air doors and control valves.

II. Vacuum switches, solenoids, and reservoirs

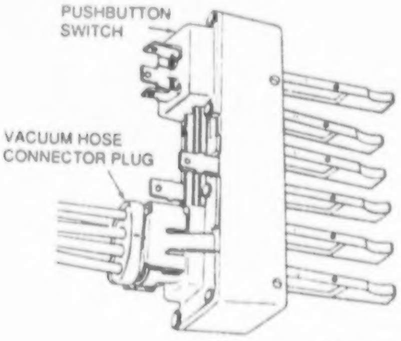
A. Vacuum switches select vacuum paths for engine intake vacuums. Vacuum switches also control the flow of coolant within the heater core, change the positions of air doors, and direct air flow to specific registers. There are two basic categories of vacuum switches: rotary and linear.

1. Two important parts of a rotary vacuum switch are a rotating vacuum plate and a stationary plate, both of which are drilled through with slots. The movement of the heater control panel levers causes the rotary vacuum plate to rotate around a fixed axis. This movement allows slots in the rotating plate to align with slots in the stationary plate. A vacuum is created in these aligned slots, and, as a result, a particular mechanical function is activated. When the plate moves again, different holes in the vacuum and stationary plates are aligned, allowing a different function to be activated.



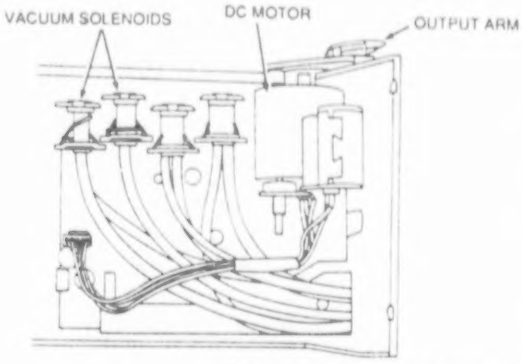
Courtesy of Murray Corporation

2. The linear vacuum switch also uses a moveable plate and a stationary plate, both of which are drilled through with slots. The movement of the heater control levers or buttons pushes or pulls the moveable plate across the fixed plate, allowing for the alignment of slots in both plates. A vacuum is created in these slots, thereby activating a particular function of the heating and air conditioning system. The particular function activated depends upon the particular alignment of slots.



Courtesy of Chrysler Motors Corporation

B. Vacuum solenoids (transducers) are electrically operated devices that allow or prohibit vacuums to pass through the solenoid.



Courtesy of Mitchell Information Services, Inc

C. Reservoirs (vacuum) are air-tight chambers connected to the source of the vacuum. By increasing the total volume of the system, vacuum capacity is accumulated.

III. Vacuum motors

A. Vacuum motors are mechanical devices that are activated as a result of a vacuum being applied to the motor's diaphragm. When the vacuum is applied, the diaphragm moves the device to which it is connected.

B. Vacuum motors fall into two categories: single source and dual source.

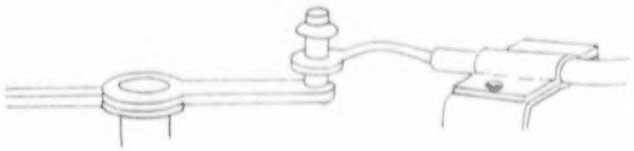
1. A single-source vacuum motor creates a vacuum on one side while maintaining atmospheric pressure on the other. The difference between the pressure in the two sides results in linear movement of a diaphragm within the motor.

2. A dual-source vacuum motor creates a vacuum on both sides of the diaphragm (housed within the motor). The difference between the size of the two vacuums changes the position of the diaphragm.

IV. Mechanical cable and mechanical linkage

A. In some automotive heating and air conditioning systems, a mechanical linkage controls the air doors. Most of these systems use bell-crank linkages. A shaft connects the air doors and valves to the bell crank. This connection can break, changing the relationship between the crank position and its intended purpose.

B. A mechanical cable controls the air doors in some automotive heating and air conditioning systems. The mechanical cable is contained in a housing that acts as a bearing for the cable and allows for adjustment of the cable's length. The range of the cable's movement varies, depending on the position in which the housing is clamped or locked. If the mechanical cable is bent, it must be replaced.

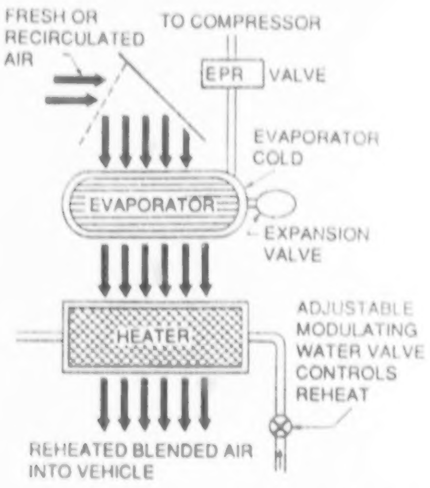


V. Plenum system and air flow

A. As was stated in previous units of this module, the air temperature entering the vehicle's passenger compartment is determined by the heater core and the evaporator, both located in the plenum chamber. Most vehicles use either the stacked-core system or the blend-air-reheat system in order to control the heater core and evaporator's effect on air temperature.

1. In the stacked-core system, air passes over the heater core and the evaporator before entering the passenger compartment. (An air access door allows fresh or recirculated air to enter.) Either a cable or a vacuum-operated heater valve modulates the amount of coolant allowed through the core (thus making the core warm or cool). The cycling of the compressor determines the temperature of the evaporator. The air flowing over the evaporator and heater core is, therefore, heated or cooled, depending on the temperature of the evaporator and heater core.

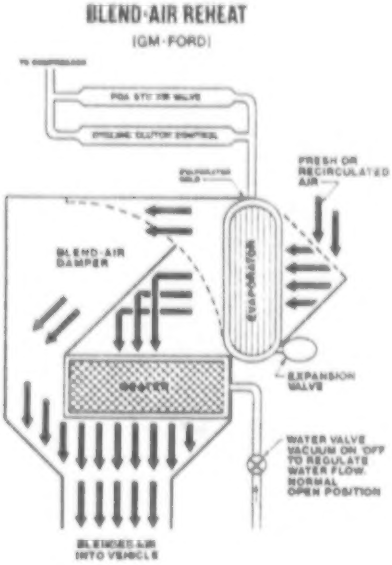
STACKED CORE REHEAT
(CHRYSLER)


FRESH OR RECIRCULATED AIR
TO COMPRESSOR
EPR
VALVE
EVAPORATOR COLD
EVAPORATOR
EXPANSION VALVE
HEATER
ADJUSTABLE MODULATING WATER VALVE CONTROLS REHEAT
REHEATED BLENDED AIR INTO VEHICLE

Courtesy of Murray Corporation

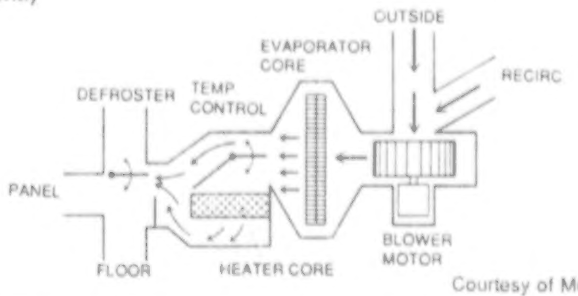
2. In the blend-air-reheat system, an air access door determines whether fresh or recirculated air enters the plenum. All air then flows across the evaporator. Depending on the position of the blend door, some of the air will then flow over the heater core (where it is heated) while the rest of the air bypasses the core (and thus remains cool). The amount of air flowing over the heater core is determined by a blend door, which is controlled from the passenger compartment.

   (NOTE: Blend doors are either cable or vacuum operated.)


BLEND-AIR REHEAT
(GM-FORD)
TO COMPRESSOR
CYCLING CLUTCH CONTROL
FRESH OR RECIRCULATED AIR
BLEND-AIR DAMPER
EVAPORATOR
HEATER
EXPANSION VALVE
WATER VALVE VACUUM ON OFF TO REGULATE WATER FLOW. NORMAL OPEN POSITION
BLENDED AIR INTO VEHICLE

B. Three modes of air direction are typically used: (1) floor registers, (2) panel registers, and (3) defrost registers.

   (NOTE: Vacuum- or cable-operated mode doors are controlled from the passenger compartment.)


OUTSIDE
EVAPORATOR CORE
RECIRC
DEFROSTER
TEMP CONTROL
PANEL
BLOWER MOTOR
FLOOR
HEATER CORE

Courtesy of Murray Corporation

VI. Procedures for inspecting and testing vacuum and mechanical control units

   A. Procedure for inspecting vacuum switch and motors

      1. Consult an appropriate service manual for information on the role of the vacuum switch in air door or control valve operation. The role of the vacuum switch may vary, depending on the vehicle.

      2. Remove appropriate dash components to access the vacuum switch.

      3. Disconnect the vacuum hose harness.

4. Test for engine vacuum at the harness.

   (NOTE: The service manual hose diagram will indicate the correct hose.)

5. If no vacuum is present, repair vacuum supply system.

6. Using a remote vacuum pump, apply vacuum to the mode door hoses. Check for proper door and mode change as indicatad by the service manual hose diagram. Replace or repair defective hoses or vacuum motors.

B. Procedure for testing the vacuum reservoir

1. Disconnect vacuum source hose from the reservoir.

2. Connect a remote vacuum pump to the reservoir.

3. Plug reservoir outlet.

4. Apply vacuum to the reservoir. Vacuum should not fall off more than one inch every 2 to 3 minutes.

C. Procedure for testing mode operation

1. Refer to the proper service manual and find a mode operation chart appropriate for the vehicle to be serviced. (The chart will possibly be similar to the one shown below.)

2. Performance test mode operation according to the steps outlined in the chart. Check for correct mode operation and temperature in each range.

3. Repair or replace defective mode hardware.

4. Repeat performance test.

Figure 13

Vacuum port	Function	Selection						
		Off	Def/flat	Floor – panel (mix)	Floor	Floor – panel (hi-lo)	Panel	Recirc
1	Outside – recirc	V	NV	NV	NV	NV	NV	V
2	Full floor	NV	NV	NV	V	NV	NV	NV
3	Floor – panel (partial)	NV	NV	V	V	V	NV	NA
4	Panel – defrost	NV	NV	NV	NV	V	V	V
5	Source	V	V	V	V	V	V	V
6	Plugged	–	–	–	–	–	–	–

Courtesy of Ford Motor Company

AS1-L1-UX

MODULE: HEATING AND AIR CONDITIONING

HEATING AND AIR CONDITIONING CONTROL DEVICES

Instructions: Do the following tasks and answer the following questions. Write all responses on this sheet.

1. Define the following terms:

   Cable (control)

   Defrost door

   Temperature control cable and door

2. What kind of power do vacuum solenoids use to relay vacuum source?

3. On what basis does a dual-source vacuum motor modulate diaphragm position?

4. The bell crank converts linear motion into what kind of motion?

5. Name three air modes used in a typical automotive heating and air conditioning system.

6. Where can the service technician obtain the mode operation chart for a specific vehicle?

MODULE: HEATING AND AIR CONDITIONING

HEATING AND AIR CONDITIONING CONTROL DEVICES

(ANSWER SHEET)

1. A cable is a wire that connects the heater control on the dash to the air control doors.

   A temperature control cable connects the temperature lever on the control panel to the temperature control door in the plenum. The temperature control door is moved by the temperature control cable.

   A vacuum control is a diaphragm that moves as a result of the creation of a vacuum. The vacuum control can open and close air doors and control valves.

   Vacuum control diaphragm that moves as a result of the creation of a vacuum. The vacuum control can open and close air doors and control valves.

2. Electrical power
3. The difference between the vacuum sources in the motor
4. Rotary
5. Floor register, panel register, defrost register
6. Air conditioning service manual

MODULE: HEATING AND AIR CONDITIONING

PROCEDURE FOR DASH REMOVAL

Instructions: Do the following tasks on a separate sheet of paper.

(HINT: Use an appropriate service manual.)

1. Record the make, model, and the year of the vehicle to be serviced.
2. Develop a written procedure for removing the dash components and hardware in order to gain access to the heater panel control switches.

JS1-L1-UX

MODULE: HEATING AND AIR CONDITIONING

TESTING VACUUM CONTROL UNITS

Equipment:

Selected vacuum circuits
Service manual
Vacuum pump and gauge
Hoses and adapters
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Using the procedure outlined below, test the vacuum panel control unit. ___ ___ ___ ___

   a. Use service manual vacuum control schematic to determine the role of the panel control in heater and air conditioning operation.

   b. Complete AS2-L1-UX.

   c. Using the procedure developed in question 2 of AS2-L1-UX, remove dash components and hardware to access the heater panel control switch.

   d. Disconnect vacuum switch from vacuum harness.

   e. Using vacuum schematic, determine supply hose. Test for vacuum at the harness. With the engine running, vacuum at the harness should be equal to engine vacuum. Repair as needed. Record observations.

   f. Using a vacuum pump and hose schematic, run system at each mode control. Observe operation. Repair or replace defective servo motor or vacuum harness. Record observations.

3. Using the procedure outlined below, test servo motor. ___ ___ ___ ___

   a. Using a remote vacuum pump, connect hose to servo motor.

b. Apply vacuum to all vacuum motors and observe their operation. Record observation.

c. Vacuum should not leak down.

d. Repair or replace as needed.

4. Using the procedure outlined below, test vacuum solenoids. ____

a. Attach vacuum gauge to vacuum switch outlet.

b. Start engine.

c. Activate solenoid through the panel control.

d. If no vacuum is present, test vacuum inlet for vacuum. Make repairs as needed. Record observations.

e. If vacuum is present, use a voltmeter to check for source voltage when solenoid is energized by panel control. Make repairs as needed. Record observations.

Average of above evaluations* ____

(*This average is a partial evaluation for Competency Gg4. Final evaluation for Gg4 will be made at the end of JS4-L2-UXI.)

JS2-L1-UX

MODULE: HEATING AND AIR CONDITIONING

TESTING VACUUM RESERVOIR AND CHECK-VALVE

Equipment:

Vacuum gauge
Safety glasses

Procedure: Evaluation 3 2 1 N

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Following the procedure outlined below, test vacuum reservoir and check-valve. ___ ___ ___ ___

   a. Locate vacuum reservoir.

   b. Disconnect reservoir outlet.

   c. Connect a tee and vacuum gauge to system.

   d. Start engine and build vacuum in reservoir. Record observations.

      (NOTE: If vacuum is not within 1 inch of manifold vacuum, find and repair the leak.)

   e. Shut off engine.

Average of above evaluations* ___ ___ ___ ___

(*This average is a partial evaluation for Competency Gg4. Final evaluation for Gg4 will be made at the end of JS4-L2-UXI.)

MODULE: HEATING AND AIR CONDITIONING

TESTING MODE DOOR OPERATION AND MECHANICAL LINKAGE

Equipment:

Selected vehicle
Service manual
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __
2. Following the procedure outlined below, test the mechanical linkage. __ __ __ __
    a. Operate mechanical panel control.
    b. Observe mode door bell crank for proper operation.
    c. Listen for mode change.
    d. Check cable for kinks, replace if kinked. Do not straighten kinked cables.
    e. Check for full bell crank movement. Adjust as needed.
3. Following the procedure outlined below, check mode operation. __ __ __ __
    a. Obtain mode chart from the service manual.
    b. Follow performance test procedure outlined in the chart.
    c. Check for correct mode operation. Record observations.
    d. Repair or replace mechanical and vacuum hardware mode operation.
    e. Repeat performance test. Record observations.

Average of above evaluations* __ __ __ __

(*This average is a partial evaluation for Competency Gg4. Final evaluation for Gg4 will be made at the end of JS4-L2-UXI.)

MODULE: HEATING AND AIR CONDITIONING

UNIT X: DIAGNOSING AND REPAIRING AUTOMOTIVE HEATING AND AIR CONDITIONING CONTROL DEVICES

UNIT X TEST

SECTION A. Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.

____ 1. In an automobile bilevel air flow is achieved when warm and cool air simultaneously flows from the floor and dash registers.

____ 2. Registers are screened openings through which outside air can enter a vehicle's air flow system.

____ 3. Vacuum solenoids (relays) allow or prevent the movement of vacuums.

____ 4. The rotary vacuum switch uses a moveable plate and a stationary plate, both of which are drilled through with slots.

____ 5. There are three basic categories of vacuum switches: rotary, linear, and cable controlled.

____ 6. A single-source vacuum motor creates a vacuum on both sides.

____ 7. A dual-source vacuum motor creates a vacuum on one side while maintaining atmospheric pressure on the other.

____ 8. In an automotive heating and cooling system that uses bell-crank linkages, air doors and valves are connected to the bell crank by a dual cable system.

____ 9. In the stacked-core system, air passes over the heater core and through the evaporator before entering the passenger compartment.

____ 10. In the blend-air-reheat system, an air access door determines whether fresh or recirculated air enters the plenum chamber.

SECTION B. Select the best answer from the five choices listed.

____ 11. In the stacked-core system, the amount of coolant allowed to pass through the heater core is controlled by either

a. a desiccant bag or a solenoid.
b. a cable- or vacuum-operated heater valve.
c. an orifice tube or an aqua door.
d. a drier or a spring-loaded thermostat.
e. a pressurized drain tube or a vacuum pump.

____ 12. A vehicle's heater control panel is located on the

a. inside of the plenum chamber.
b. outside of the plenum chamber.
c. fire wall.
d. dash board.
e. heater core.

____ 13. Blend doors are operated by either a

a. cable or vacuum.
b. solenoid or thermistor.
c. thermostat or MAP sensor.
d. steel spring or slide bar.
e. blower fan or ram air.

____ 14. During testing of a vacuum switch and motors, a vacuum can be applied to the mode door hoses with

a. an air compressor.
b. a vacuum test hose.
c. a vacuum/mechanical motor.
d. a remote vacuum pump.
e. a vacuum piston.

____ 15. An important moving part of a vacuum control is the

a. plunger.
b. piston.
c. plug.
d. slide bar.
e. diaphragm.

(NOTE: The student must obtain a minimum score of _____ on the Unit X Test in order to receive an evaluation for Competency Gg4.)

ANSWERS TO UNIT X TEST

1. t
2. f
3. t
4. t
5. f
6. f
7. f
8. f
9. t
10. t
11. b
12. d
13. c
14. d
15. e

MODULE: HEATING AND AIR CONDITIONING

UNIT XI: DIAGNOSING AUTOMATIC AND SEMIAUTOMATIC CONTROL SYSTEMS

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose automatic and semiautomatic heating and air conditioning control systems. The student will demonstrate mastery of the material by achieving a score of _____ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify terms and definitions associated with diagnosing automatic and semiautomatic heating and cooling control systems (Competency Gg4, Unit XI Test).

II. Identify automatic and semiautomatic heating and cooling control system components (Competency Gg4, Unit XI Test).

III. Identify the basic operating principles of automatic and semiautomatic heating and cooling control systems (Competency Gg4, Unit XI Test).

Lesson 2.

I. Identify the characteristics that distinguish automatic heating and cooling control systems from semiautomatic systems (Competency Gg4, Unit XI Test).

II. Identify procedures for testing semiautomatic heating and cooling control systems (Competency Gg4, Unit XI Test).

III. Identify procedures for testing automatic heating and cooling control systems (Competency Gg4, Unit XI Test).

IV. Demonstrate the ability to:

  a. Identify automatic and semiautomatic heating and cooling control system components (Competency Gg4, JS1-L2-UXI).

  b. Performance test a semiautomatic heating and cooling control system (Competency Gg4, JS2-L2-UXI).

  c. Test components of the semiautomatic heating and cooling system (Competency Gg4, JS3-L2-UXI).

  d. Performance test an automatic heating and cooling control system (Competency Gg4, JS4-L2-UXI).

ASE TASKS COVERED IN THIS UNIT

I. The job sheets in this unit cover ASE tasks G047, G063, G064, G065, G066, and G067.

MODULE: HEATING AND AIR CONDITIONING

UNIT XI: DIAGNOSING AUTOMATIC AND SEMIAUTOMATIC CONTROL SYSTEMS

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: OPERATION OF AUTOMATIC AND SEMIAUTOMATIC HEATING AND COOLING CONTROL SYSTEMS

    a. Information outline

    b. Assignment sheet

    AS1-L1-UXI: Automatic and Semiautomatic Heating and Cooling Control Systems

2. Lesson 2: DIAGNOSING AUTOMATIC AND SEMIAUTOMATIC CONTROL SYSTEMS

    a. Information outline

    b. Assignment sheets

    AS1-L2-UXI: Procedure for Resistance Testing an Ambient Temperature Sensor
    AS2-L2-UXI: Procedure for Resistance Testing an In-Vehicle Sensor
    AS3-L2-UXI: Procedure for Performance Testing an Automatic Heating and Cooling Control System
    AS4-L2-UXI: Procedure for Testing Air Conditioning and Heating Components

    c. Job sheets

    JS1-L2-UXI: Identifying Automatic or Semiautomatic Heating and Cooling System Control Components
    JS2-L2-UXI: Performance Testing a Semiautomatic Heating and Cooling Control System
    JS3-L2-UXI: Testing Components of the Semiautomatic Heating and Cooling System
    JS4-L2-UXI: Performance Testing an Automatic Heating and Cooling control System

E. Unit test

F. Answers to unit test

REFERENCES

Carter Carburetor Division, ACF Industries, Inc. Automotive Air Conditioning Theory and Practice.

Mitchell Information Services, Inc. Heating and Air Conditioning Systems. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1987.

Mitchell International, Inc. Automotive Air Conditioning Basic Service Training Manual. 21st ed. San Diego, CA: Mitchell International Inc., 1988.

Mitchell Manuals, Inc. 1984 Edition Automotive Air Conditioning Basic Service Training Manual. San Diego, CA: Mitchell Manuals, Inc., 1984.

Murray Corporation. Dealer Education Program Temperature Control Clinic Workbook. Cockeysville, MD: Murray Corporation, 1988.

NOTES TO THE INSTRUCTOR

I. Suggested approaches to teaching this unit

   A. Students should do AS1-L1-UXI and AS1-L2-UXI before taking the Unit XI test. Students should do AS1-L2-UXI and AS2-L2-UXI in conjunction with JS3-L2-UXI. Students should do AS3-L2-UXI in conjunction with JS4-L2-UXI. Students should do AS4-L2-UXI in conjunction with JS2-L2-UXI.

MODULE: HEATING AND AIR CONDITIONING

UNIT XI: DIAGNOSING AUTOMATIC AND SEMIAUTOMATIC CONTROL SYSTEMS

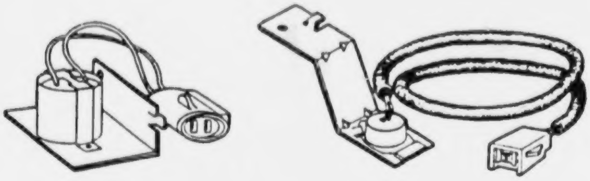
LESSON 1: OPERATION OF AUTOMATIC AND SEMIAUTOMATIC HEATING AND COOLING CONTROL SYSTEMS

I. Terms and definitions

- A. Analog processing--A process by which a semiautomatic control system handles sensor information and output actuation of the transducer in a nonfeedback manner.
- B. Feedback--Information supplied to the air conditioning microprocessor. The microprocessor uses the information to modify the processor's actuation of automatic heating and cooling system components.
- C. Inputs--Electrical signals created by sensors, position indicators, control panel switches, etc. Inputs supply the analog or microprocessor unit with information.
- D. Microprocessor--An automatic air conditioning and cooling fan control device that adjusts system operation on the basis of sensor inputs and feedback information from system outputs.
- E. Mode door sensor--A feedback position indicator for the blend door.
- F. Sensor input--An electrical signal generated by the sensor. The sensor input conveys information to the analog or microprocessor controller.
- G. Sun-load sensor--A device that measures the presence of sunlight for microprocessor input.
- H. Transducer--A device that controls vacuum output from a varying electrical input.
- I. Vacuum sensor--A device that measures intake manifold under load and informs the microprocessor of heavy load conditions.

II. Automatic and semiautomatic control system components

- A. Input devices
  - 1. The ambient temperature sensor measures the outside temperature and relays the information to the microprocessor. The microprocessor modifies air conditioning system operation based on the outside temperature and thereby prevents system damage and maintains proper passenger compartment temperature.

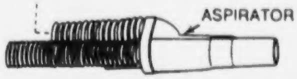


AMBIENT TEMPERATURE SWITCHES

Courtesy of Murray Corporation

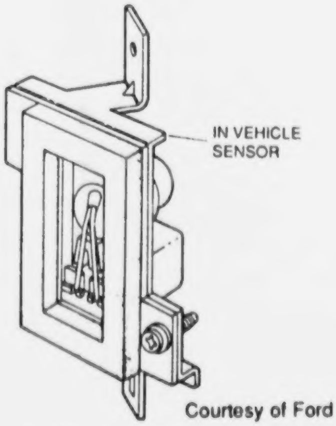
2. An aspirator sensor uses venturi action (generated by blower activity) to draw a sample of passenger compartment air. The aspirator analyses air samples and converts its findings into an electrical signal, which is then conveyed to the microprocessor. The microprocessor uses the information to modify system operation in order to maintain the desired passenger compartment temperature.

   (NOTE: Most aspirator sensors are located in the outlet duct closest to the evaporator.)



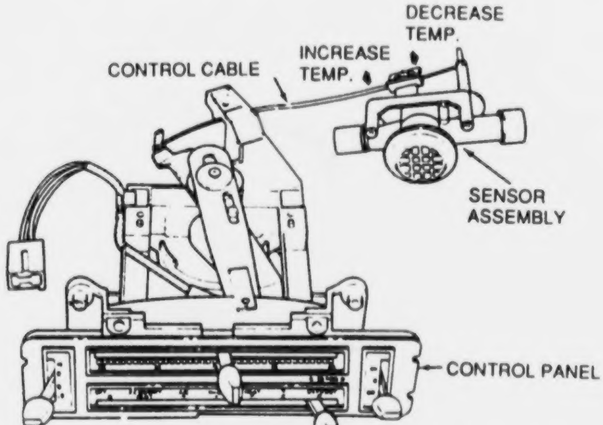
Courtesy of Mitchell Information Services, Inc.

3. In-vehicle temperature sensors are thermistor devices mounted in the passenger compartment. The sensors measure temperature and convey the measurement to the computer.



Courtesy of Ford Motor Company

4. A temperature control input is a signal sent by the dash temperature control device. The microprocessor uses the signal to regulate passenger compartment temperature.

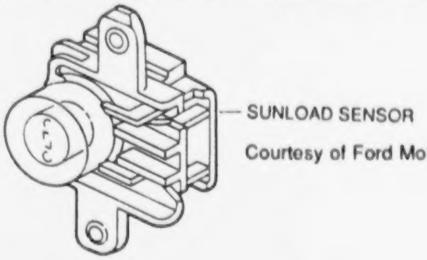


Courtesy of Mitchell Information Services, Inc.

5. The wide-open-throttle (WOT) sensor informs the microprocessor of high engine load conditions (i.e. throttle linkage open more than 85%); the microprocessor turns off the air conditioning compressor until the load is reduced.

   (NOTE: The wide-open-throttle switch is found on most front-wheel-drive cars.)

6. A sun-load sensor uses a photo voltaic cell to sense the presence of sunlight. When sunlight is present, the sun-load sensor increases air conditioning operation.

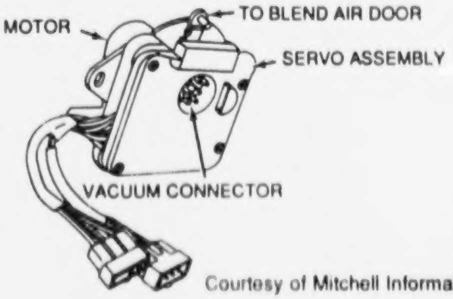

SUNLOAD SENSOR

Courtesy of Ford Motor Company

SUNLOAD SENSOR

B. Output devices

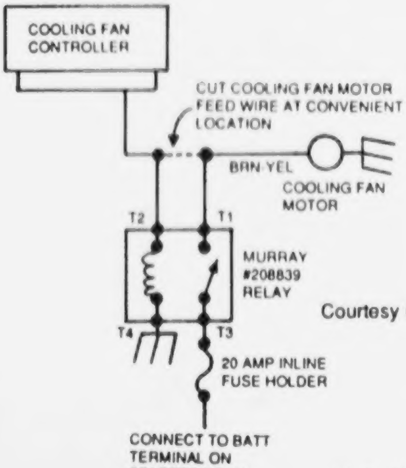
1. The vacuum transducer modulates a vacuum that controls the blend door. (Control of the blend door allows for control of outlet temperature.) The vacuum transducer is activated by an analog electronic controller.


MOTOR
TO BLEND AIR DOOR
SERVO ASSEMBLY
VACUUM CONNECTOR

Courtesy of Mitchell Information Services, Inc.

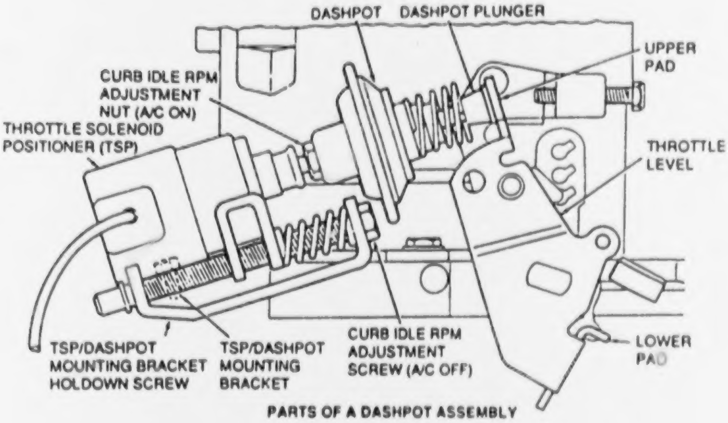
2. The computer-controlled compressor clutch-cycling relay functions in much the same way as other relays. The coil on this relay, however, is activated by the microprocessor.

3. The cooling fan relay operates much like the computer-controlled compressor clutch-cycling relay. The cooling fan relay, however, controls the cooling fan instead of the compressor.


COOLING FAN CONTROLLER
CUT COOLING FAN MOTOR FEED WIRE AT CONVENIENT LOCATION
BRN-YEL
COOLING FAN MOTOR
T2
T1
MURRAY #208839 RELAY
T4
T3
20 AMP INLINE FUSE HOLDER
CONNECT TO BATT TERMINAL ON STARTER RELAY

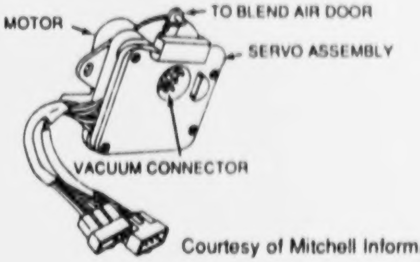
Courtesy of Murray Corporation

4. The throttle position controller is a computer-controlled solenoid or motor that is activated during air conditioning operation.


DASHPOT
DASHPOT PLUNGER
UPPER PAD
CURB IDLE RPM ADJUSTMENT NUT (A/C ON)
THROTTLE SOLENOID POSITIONER (TSP)
THROTTLE LEVEL
TSP/DASHPOT MOUNTING BRACKET HOLDOWN SCREW
TSP/DASHPOT MOUNTING BRACKET
CURB IDLE RPM ADJUSTMENT SCREW (A/C OFF)
LOWER PAD

PARTS OF A DASHPOT ASSEMBLY

5. Vacuum motor solenoids control or modulate vacuum door positions on the basis of computer signals.

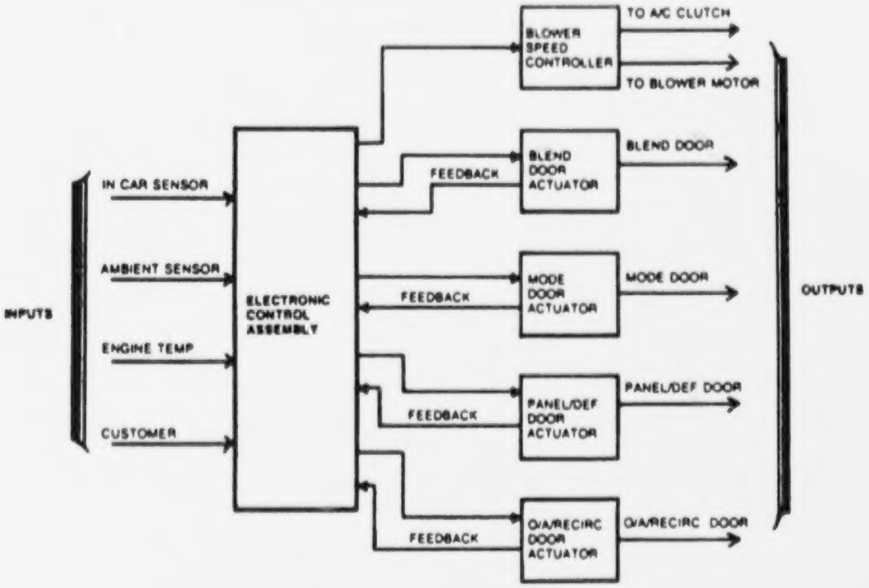

MOTOR
TO BLEND AIR DOOR
SERVO ASSEMBLY
VACUUM CONNECTOR

Courtesy of Mitchell Information Services, Inc.

III. Basic operation of semiautomatic and automatic heating and cooling systems

A. The semiautomatic heating and cooling system usually adjusts the blend door according to information provided by two sensors: the aspirator sensor (which monitors outlet temperature) and the in-vehicle sensor. The driver establishes a desired temperature, allowing the sensors to send electronic signals to a control unit. The control unit then sends an electrical signal to the transducer, which, in turn, controls the blend door position.

B. The automatic heating and cooling system maintains the desired passenger compartment temperature through the use of many sensor input and output signals. These signals allow the microprocessor to control many engine, air conditioning, heater, and blend door operations. Automatic systems use a computer not only to activate heating and air conditioning components, but also to monitor component operation. The information that the computer receives as a result of monitoring components is called feedback. Feedback allows the computer to adjust the mechanical air conditioning controls in order to achieve the desired temperature.


INPUTS
IN CAR SENSOR
AMBIENT SENSOR
ENGINE TEMP
CUSTOMER
ELECTRONIC CONTROL ASSEMBLY
BLOWER SPEED CONTROLLER
TO A/C CLUTCH
TO BLOWER MOTOR
FEEDBACK
BLEND DOOR ACTUATOR
BLEND DOOR
FEEDBACK
MODE DOOR ACTUATOR
MODE DOOR
FEEDBACK
PANEL/DEF DOOR ACTUATOR
PANEL/DEF DOOR
FEEDBACK
O/A/RECIRC DOOR ACTUATOR
O/A/RECIRC DOOR
OUTPUTS

Courtesy of Ford Motor Company

C. Most automatic heating and cooling controllers that use a microprocessor can store trouble codes. This mircoprocessor has a specific diagnostic mode similar to the computerized engine controller.

(NOTE: Service modes can be used to perform various tests on air conditioning systems at one time. After trouble codes have been displayed, the service modes can be used to activate the mechanical components and test the sensors.)

AS1-L1-UXI

MODULE: HEATING AND AIR CONDITIONING

AUTOMATIC AND SEMIAUTOMATIC HEATING AND COOLING CONTROL SYSTEMS

Instructions: Do the following tasks and answer the following questions. Write all responses on this sheet.

1. Define the following terms:

   Ambient temperature sensor

   Aspirator

   Feedback

   Mode door sensor

   In-vehicle sensor

   Sun-load sensor

   WOT switch

2. What device converts electrical signals into a specific vacuum?

3. Describe the function of feedback in an automatic air conditioning system

MODULE: HEATING AND AIR CONDITIONING

AUTOMATIC AND SEMIAUTOMATIC HEATING AND COOLING CONTROL SYSTEMS

(ANSWER SHEET)

1. An ambient temperature sensor measures outside air temperature and converts the measurement into an electrical signal.

   An aspirator draws a sample of the passenger compartment air for the purpose of measuring its temperature.

   Feedback is information supplied to the air conditioning microprocessor for the purpose of modifying the processor's output actuation of automatic system components.

   A mode door sensor is a feedback position indicator for the microprocessor.

   An in-vehicle sensor is a device that measures passenger compartment air temperature.

   A sun-load sensor measures the presence of bright sunlight for microprocessor input.

   The WOT switch measures the condition of engine wide-open throttle to turn off the air conditioner under heavy engine load.

2. Vacuum transducer

3. Feedback is the information that the computer receives as a result of monitoring heating and air conditioning components. Feedback allows the computer to adjust the mechanical air conditioning controls in order to achieve the desired temperature.

MODULE: HEATING AND AIR CONDITIONING

UNIT XI: DIAGNOSING AUTOMATIC AND SEMIAUTOMATIC CONTROL SYSTEMS

LESSON 2: DIAGNOSING AUTOMATIC AND SEMIAUTOMATIC CONTROL SYSTEMS

I. Procedures for identifying semiautomatic and automatic heating and cooling systems

  A. Obtain the appropriate wiring diagram for the heating and cooling system to be serviced.

  B. Identify blend door control system.

    1. In automatic heating and cooling systems, the blend door uses a position sensor. Such systems may have self-diagnostic capabilities.

    2. Semiautomatic systems use a blend door activator without a sensor.

    3. In a manual system, the blend door is controlled by a cable rather than by an activator or sensor.

II. Procedures for testing semiautomatic heating and cooling systems

  A. Procedure for testing a semiautomatic heating and cooling system

    1. Obtain a general diagnosis chart from a proper service manual.

    2. Test blower.

      a. Make sure that the blower operates in every mode.

      b. Make sure that air comes from the proper duct during operation in each mode.

      c. Make sure that the blower switch operates the blower at the appropriate speeds.

    3. Make sure that the air conditioning compressor cycles in accordance with the switch position.

    4. Make sure that the temperature of air discharged from outlets can be properly altered by the panel control.

    5. Make sure that the temperature remains stable during a variety of driving conditions.

    6. If any problems are revealed in the above tests, test the appropriate individual components.

  B. Procedures for testing various failures of the semiautomatic heating and cooling system

    1. Procedure for testing an inoperative blower or a blower that functions at the inappropriate speed

      a. Using the proper wiring schematic, identify the blower speed control.

      b. Test the blower motor and the circuit according to manufacturer's recommendations.

2. Procedure for diagnosing inappropriate mode control selection

    a. Using the vacuum schematic, determine the system's method of mode control.

    b. Following manufacturer's recommended procedures, test for proper mode control.

3. Procedure for diagnosing an air conditioning compressor that does not cycle

    a. Make sure that the cause of improper compressor clutch cycling is not due to improper freon pressure (level).

    b. Using a wiring schematic, determine the current path by which the air conditioner's compressor is controlled.

    c. Following manufacturer's recommended procedures, test the compressor clutch circuit.

4. Procedure for diagnosing temperature modulation

    a. Determine the type of temperature control used by the system.

    b. Following manufacturer's recommended procedures, diagnose improper temperature variations. Be sure to use a vacuum and electrical schematic.

C. Procedures for testing servo motor and vacuum motor

1. Procedure for testing servo motor

    a. Activate system and visually check for servo motor movement.

    b. If servo motor does not move, test for an electrical signal from the electronic control unit. If no signal is detected, replace the control unit or the wiring.

    c. If the electronic control unit is producing an electrical signal, replace or repair the servo motor unit.

    d. If the electronic control unit is producing an electrical signal and there is servo motor movement, repair servo motor linkage or air door.

2. Procedure for testing vacuum servo

    a. Activate system and visually check for servo movement.

    b. If no movement is detected, test vacuum switch and supply.

    c. If vacuum is present, test servo motor. Repair or replace the motor as necessary.

D. Procedures for testing individual components

1. Procedure for testing the ambient temperature sensor

    a. Remove the sensor.

    b. Resistance test the sensor according to the appropriate service information, scale, and time.

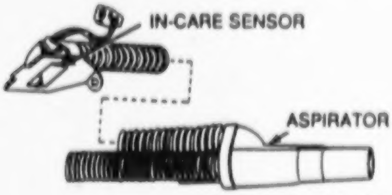
c. The sensor's resistance should fall within specifications (usually 255-335 ohms at 70°F).

2. Procedure for testing the in-vehicle sensor

a. Disconnect sensor harness.

b. Resistance test sensor according to the procedure outlined in an appropriate service manual.

c. Resistance should fall within manufacturer's specifications.



Courtesy of Mitchell Information Services, Inc.

3. Procedure for testing the control panel

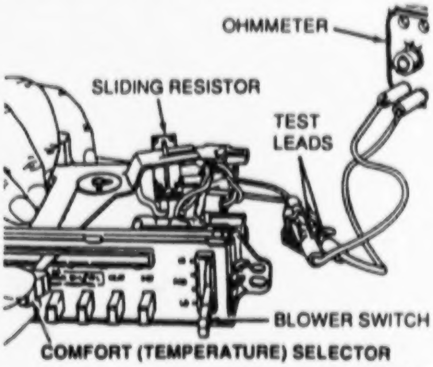
a. Disconnect power supply.

b. Remove control panel.

c. Disconnect temperature lever harness.

d. Connect ohmmeter.

e. Slide temperature control; resistance should change evenly.



Courtesy of Chrysler Motors Corporation

III. Procedures for testing automatic heating and cooling systems

(NOTE: The below tests are performed after the system has been checked to determine that freon pressure [level] is correct.)

A. Automatic heating and cooling system testing falls into two categories: noncomputer diagnostics and computer diagnostics. Noncomputer diagnostics involve essentially the same system tests as in the semiautomatic testing procedures.

B. Computer self-test

1. Using the proper service manual, enter the computer self-test mode.

2. Record computer trouble codes.
3. Use the proper failure code chart to interpret the codes.
4. Clear codes and performance test the system.

MODULE: HEATING AND AIR CONDITIONING

PROCEDURE FOR RESISTANCE TESTING AN AMBIENT TEMPERATURE SENSOR

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for resistance testing the vehicle's ambient temperature sensor.

MODULE: HEATING AND AIR CONDITIONING

PROCEDURE FOR RESISTANCE TESTING AN IN-VEHICLE SENSOR

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for resistance testing the in-vehicle sensor.

MODULE: HEATING AND AIR CONDITIONING

PROCEDURE FOR PERFORMANCE TESTING AN AUTOMATIC HEATING AND COOLING CONTROL SYSTEM

Instructions: Do the following tasks on a separate sheet of paper.

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for performing a computer self-test on the heating and cooling system to be serviced.

MODULE: HEATING AND AIR CONDITIONING

PROCEDURE FOR TESTING AIR CONDITIONING AND HEATING COMPONENTS

Instructions: **Do the following tasks on a separate sheet of paper.**

(HINT: Use an appropriate service manual.)

1. Record the make, model, and year of the vehicle to be serviced.
2. Develop a written procedure for testing the vehicle's blower motor and blower motor control circuit.
3. Develop a written procedure for testing the vehicle's system for proper mode control.
4. Develop a written procedure for testing the vehicle's compressor clutch circuit.
5. Develop a written procedure for diagnosing improper temperature variations.

MODULE: HEATING AND AIR CONDITIONING

IDENTIFYING AUTOMATIC AND SEMIAUTOMATIC HEATING AND COOLING SYSTEM CONTROL COMPONENTS

Equipment:

Service manual
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. _ _ _ _

2. Obtain an electrical wiring and hose schematic for the vehicle to be serviced. Using the information provided in items a through d below, identify the system's blend door control. _ _ _ _

   a. If the blend door control has a position feedback sensor, it is an automatic system.

   b. If the system has a blend door servo motor or vacuum motor but the wiring schematic does not indicate that a feedback sensor controls the door's position, the system is semiautomatic.

   c. In manual systems, the blend door is controlled by a cable.

   d. Record the type of system being serviced.

3. Using a schematic, list the system's components below. _ _ _ _

Average of above evaluations* _ _ _ _

(*This average is a partial evaluation for Competency Gg4. Final evaluation for Gg4 will be made at the end of JS4-L2-UXI.)

MODULE HEATING AND AIR CONDITIONING

PERFORMANCE TESTING A SEMIAUTOMATIC HEATING AND COOLING CONTROL SYSTEM

Equipment:

Service manual
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. __ __ __ __

2. Following the procedure outlined below, perform area tests on a semiautomatic system. __ __ __ __

   a. Obtain the proper diagnostic chart for the system to be tested.

   b. Perform a blower test.

      What speeds does the blower have?

      Does it operate in the appropriate mode?

      Yes _____ No _____

   c. Performance test the air conditioner's compressor cycle.

      Does the compressor cycle in the maximum mode?

      Yes _____ No _____

      Does it cycle according to temperature selection?

      Yes _____ No _____

d. Perform temperature modulation test.

Does the temperature of the air leaving the outlet fall within 3 degrees Fahrenheit of the temperature selected?

Yes _____ No _____

Does the temperature change when the temperature setting is changed?

Yes _____ No _____

Is the temperature stable over the range of control?

Yes _____ No _____

3. If the automatic system fails any of the above area tests, test the appropriate individual components. Follow the procedure outlined below. — — — —

a. If the blower is not functioning at the desired speed, complete items 1 and 2 of AS4-L2-UXI. Use a wiring schematic to determine the type of speed control that the blower uses. Using the procedure developed in item 2 of AS4-L2-UXI, test the blower motor and the blower motor circuit.

b. If the mode control fails, use a vacuum schematic to determine the method of mode control. Complete items 1 and 3 of AS4-L2-UXI. Using the procedure developed in item 3 of AS4-L2-UXI, test the mode control.

c. If air conditioning compressor clutch cycle fails, use a wiring schematic to determine the clutch cycle system. Complete items 1 and 4 of AS4-L2-UXI. Using the procedure developed in item 4 of AS4-L2-UXI, test the compressor clutch circuit.

d. If temperature modulation fails, use a wiring and vacuum schematic to determine the method of temperature bypass modulation. Complete items 1 and 5 of AS4-L2-UXI. Using the procedure developed in item 5 of AS4-L2-UXI, test the compressor clutch circuit.

Average of above evaluations* — — — —

(*This average is a partial evaluation for Competency Gg4. Final evaluation for Gg4 will be made at the end of JS4-L2-UXI.)

JS3-L2-UXI

MODULE: HEATING AND AIR CONDITIONING

TESTING COMPONENTS OF THE SEMIAUTOMATIC HEATING AND COOLING SYSTEM

Equipment:

VOM
Service manual
Safety glasses

Evaluation
3 2 1 N

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet. ___ ___ ___ ___

2. Following the procedure outlined below, resistance test the ambient temperature sensor. ___ ___ ___ ___

    a. Remove the ambient temperature sensor.

    b. Complete AS1-L2-UXI.

    c. Following the procedure developed in AS1-L2-UXI, resistance test the ambient temperature sensor.

    d. Compare the resistance of the ambient temperature sensor to range chart provided by the manufacturer. Record observations.

3. Following the procedure outlined below, resistance test an in-vehicle sensor. ___ ___ ___ ___

    a. Remove in-vehicle sensor.

    b. Complete AS2-L2-UXI.

    c. Following the procedure developed in AS2-L2-UXI, resistance test the sensor.

    d. Compare test results to manufacturer's range chart. Record observations.

4. Following the procedure outlined below, resistance test sliding resistor. _ _ _ _

   a. Remove resistor control panel.

   b. Resistance test sliding resistor. Switch should range evenly without skips or opens. Record observations.

5. Following the procedure outlined below, resistance test the aspirator. _ _ _ _

   a. Remove aspirator.

   b. While blower is on, cover the sensor opening with a piece of paper. The paper should be drawn to the opening. Record observations.

Average of above evaluations* _ _ _ _

(*This average is a partial evaluation for Competency Gg4. Final evaluation for Gg4 will be made at the end of JS4-L2-UXI.)

MODULE: HEATING AND AIR CONDITIONING

PERFORMANCE TESTING AN AUTOMATIC HEATING AND COOLING CONTROL SYSTEM

Equipment:

Service manual
Thermometer
Safety glasses

Procedure:

Step		Evaluation 3 2 1 N
1.	Wear safety glasses while doing all procedures on this job sheet.	_ _ _ _
2.	Following the procedure outlined below, perform a computer self-test.	_ _ _ _

   a. Complete AS3-L2-UXI.

   b. Following the procedure developed in AS3-L2-UXI, obtain trouble codes and clear codes.

   c. Record codes.

Average of above evaluations* _ _ _ _

(*This average is a partial evaluation for Competency Gg4. Final evaluation for Gg4 will be made at the end of this job sheet.)

FINAL EVALUATION INSTRUCTIONS

I. Determine the student's final evaluation for Gg1 by averaging the evaluations of JS1-L1-UIX, JS2-L1-UIX, JS3-L1-UIX, JS1-L1-UX, JS2-L1-UX, JS3-L1-UX, JS1-L2-UXI, JS2-L2-UXI, JS3-L2-UXI, and JS4-L2-UXI.

	Evaluation			
	3	2	1	N
JS1-L1-UIX	___	___	___	___
JS2-L1-UIX	___	___	___	___
JS3-L1-UIX	___	___	___	___
JS1-L1-UX	___	___	___	___
JS2-L1-UX	___	___	___	___
JS3-L1-UX	___	___	___	___
JS1-L2-UXI	___	___	___	___
JS2-L2-UXI	___	___	___	___
JS3-L2-UXI	___	___	___	___
JS4-L2-UXI	___	___	___	___
Final evaluation for Competency Gg4	___	___	___	___

MODULE: HEATING AND AIR CONDITIONING

UNIT XI: DIAGNOSING AUTOMATIC AND SEMIAUTOMATIC CONTROL SYSTEMS

UNIT XI TEST

SECTION A. **Match the terms below with their appropriate definitions.**

____ 1. A device that draws a sample of the passenger compartment air for the purpose of measuring its temperature.

____ 2. A device that measures passenger compartment air temperature.

____ 3. Information supplied to the air conditioner's microprocessor. This information modifies the microprocessor's output actuation of automatic system components.

____ 4. Electrical signals created by sensors, position indicators, control panel, etc. These signals relate information to the analog or microprocessor unit.

____ 5. A device that measures intake manifold under load and informs the microprocessor of heavy load conditions.

____ 6. Feedback position indicator for the microprocessor.

____ 7. An automatic air conditioner and cooling fan controller that adjusts system operation on the basis of sensor input and feedback information from system outputs.

____ 8. Upon detecting engine wide-open throttle, this device turns off the vehicle's air conditioning system.

____ 9. A device that creates a variable vacuum output from a varying electrical input.

a. Ambient temperature sensor

b. Aspirator sensor

c. Feedback

d. Inputs

e. Micro-processor

ab. Mode door sensor

ac. In-vehicle sensor

ad. Transducer

ae. Vacuum sensor

bc. WOT sensor

SECTION B. **Read the statements below. Place a T or F in the blank beside each statement to indicate whether it is true or false.**

____ 10. Temperature control input originates from a computer.

____ 11. The sun-load sensor magnifies sunlight to heat the air in a vehicle's passenger compartment.

____ 12. The vacuum transducer uses an electrical signal to modulate the amount of vacuum applied to the air blend door.

____ 13. The coil on the computer-controlled compressor clutch-cycling relay is activated by the microprocessor.

____ 14. The throttle position controller is essentially a type of transducer.

____ 15. Automatic vehicle heating and cooling control systems typically use only two sensors: the aspirator sensor and the in-vehicle sensor.

____ 16. If an automotive heating and cooling control system has a blend door activator instead of a door-control sensor, the system is semiautomatic.

____ 17. If an automotive heating and cooling control system has no blend door, the system is manually controlled.

____ 18. The analog process is the manner in which a semiautomatic control system handles sensor information.

____ 19. An ambient temperature sensor measures the air outside a vehicle's passenger compartment.

____ 20. Some semiautomatic automotive heating and cooling control systems use microprocessors.

(NOTE: The student must obtain a minimum score of ____ on the Unit XI Test in order to receive an evaluation for Competency Gg4.)

ANSWERS TO UNIT XI TEST

1. b
2. ac
3. c
4. d
5. ae
6. ab
7. e
8. bc
9. ad
10. f
11. f
12. t
13. t
14. f
15. f
16. f
17. t
18. t
19. t
20. f